*Forest Research Information Paper* 162

# Ontario Forest Research Institute Publications 2001-2005:

# An Annotated Bibliography

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Ontario Forest Research Institute
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# An Annotated Bibliography

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## Abstract

Buse, L.J. (comp.). 2006. Ontario Forest Research Institute Publications 2001-2005: An Annotated Bibliography. Ontario Ministry of Natural Resources, Ontario Forest Research Institute, Sault Ste. Marie, Ontario, Forest Research Information Paper No 162. 62 p.

This bibliography compiles all publications written, co-authored, or commissioned by OFRI staff between 2001 and 2005. During this period over 200 publications were produced including 3 books, 87 journal articles, 26 reports, 11 technical notes, 5 newsletters, 47 papers/summaries in conference/workshop proceedings. Topics covered are diverse: understanding natural disturbance regimes and landscape dynamics, carbon budgets and effects of climate change on forests, results of 1998 ice storm research, silviculture studies covering everything from site preparation, tree improvement, stock production, planting, and vegetation management, to stand growth and yield, thinning, disease management and harvesting for conifer, mixedwood, and hardwood forests in the boreal and Great Lakes region of Ontario. Author and subject indexes are provided.

## Resumé

Cette bibliographie rassemble les publications rédigées, corédigées ou commandées par le personnel de l'IRFO entre 2001 et 2005. Dans cette période, plus de 200 publications ont été produites, dont 3 ouvrages, 87 articles de revues, 26 rapports, 11 notes techniques, 5 bulletins d'information, 47 mémoires ou sommaires de travaux de congrès ou d'ateliers. Les sujets traités sont très variés : caractérisation des régimes de perturbations naturelles et de la dynamique des paysages; bilan du carbone et effets des changements climatiques sur les forêts; résultats d'études menées sur la tempête de verglas de 1998; études sylvicoles couvrant tous les aspects, depuis la préparation des sites, l'amélioration des arbres, la production de stocks, la plantation et la gestion de la végétation jusqu'à la croissance et le rendement des peuplements, les coupes d'éclaircie, la gestion des maladies et la récolte de bois dans les forêts de conifères, les forêts mixtes et les forêts de feuillus de la région boréale et de la région des Grands Lacs de l'Ontario. Des index des auteurs et un index des sujets sont fournis.

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## Introduction

This annotated bibliography includes citations and abstracts for books, book chapters, journal articles, research reports, information papers, technical notes, symposium proceedings, newsletter articles, papers in conference proceedings, and other reports written, co-authored, or commissioned by OFRI staff between 2001 and 2005.

Topics covered are diverse: understanding natural disturbance regimes and landscape dynamics, carbon budgets and effects of climate change on forests, results of 1998 ice storm research, silviculture studies covering everything from site preparation, tree improvement, stock production, planting, and vegetation management, to stand growth and yield, thinning, disease management, and harvesting for conifer, mixedwood, and hardwood forests in the boreal and Great Lakes region of Ontario.

Publications are listed alphabetically by first author by year. Author names are in parentheses if not from OFRI at time of publication and only OFRI authors are included in the author index (Appendix I). As well, a subject index (Appendix II) and composite lists of each report series are provided by report number – Forest Research Reports (Appendix III), Forest Research Information Papers (Appendix IV), Forest Research Notes (Appendix V), and Climate Change Research Reports (Append VI).

The number of various types of publications produced between 2001 and 2005 are summarized in Table 1.

**Table 1.** *Summary of major publications produced by OFRI authors between 2001 and 2005.*

| Publication | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Book | 2 | - | - | 1 | - |
| Report | 5 | 4 | 9 | 3 | 5 |
| Journal article | 25 | 26 | 15 | 15 | 6 |
| Book chapter | 13 | - | - | 3 | - |
| Paper/Summary in Conference Workshop Proceeding/Web | 3 | 10 | 16 | 16 | 2 |
| Technical note | 2 | 2 | 6 | 1 | - |
| Newsletter | 2 | 1 | 1 | 1 | 1 |
| Other (e.g., internal or unpublished report) | 2 | - | 2 | 1 | 4 |
| Total | 54 | 43 | 49 | 41 | 18 |

# Publications 2001

Anderson, H.W., (E.P. Boysen), (D.C. Dey) and J.A. Rice. 2001. **Natural regeneration of hardwoods**. Pp. 393-421 *in* Regenerating the Canadian Forest. Principles and Practice for Ontario. Wagner, R.G. and S.J. Colombo, eds. Fitzhenry and Whiteside, Ltd., Markham, ON. 650 p.
(This chapter discusses the distribution of hardwood forests in Ontario, silvical features affecting their regeneration potential, appropriate silvicultural systems, and presents 5 hardwood management case studies.)

Baldwin, D.J.B., K. Weaver, F. Schnekenburger and A.H. Perera. 2001. **Sensitivity of landscape pattern indices to spatial extent, data resolution, and classification detail in the managed forest of Ontario**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Rep. No. 150. 45 p.
(We examined the sensitivity of a suite of landscape indices to changes in spatial extent, data resolution, and classification detail. Eighteen indices were chosen to represent all major aspects of landscape patterns: patchiness, shape, isolation, edge, interior, and heterogeneity. We used Landsat TM-based land cover data of Ontario's managed forest (45.5 million ha), controlling extent (2 500 to 2 560,000 ha), resolution (1 to 16 ha), and classification detail (2 to 26 classes). All of the index responses were consistent with those interpreted from previous studies of simulated and real landscapes. Sensitivity of the indices to changes in extent resolution, and classification detail varied among indices and over space.)

(Bigras, F.J.) and S.J. Colombo (eds.). 2001. **Conifer Cold Hardiness**. Kluwer Academic Publishers, Dordrecht, NL. 612 p.
(This volume provides an up-to-date synthesis by leading scientists in the study of major physiological and environmental factors regulating cold hardiness of conifer tree species. This state-of-the-art reference comprehensively explains current understanding of conifer cold hardiness ranging from the gene to the globe and from the highly applied to the very basic. Topics addressed encompass cold hardiness from the perspectives of ecology, ecophysiology, acclimation and deacclimation, seedling production and reforestation, the impacts of biotic and abiotic factors, and methods for studying and analyzing cold hardiness. (*Not available from OFRI – order directly from publisher or distributor.*))

Buse, L.J. 2001. **Ontario Forest Research Institute publications 1996-2000: A bibliography with abstracts**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 147. 105 p.
(All publications written, co-authored, or commissioned by OFRI staff between 1996 and 2000 were compiled and annotated to produce this bibliography. During this period, almost 500 publications were produced including 131 journal articles, 61 reports, 3 field guides/books, 21 technical notes, 52 newsletter/newsletter articles, 93 papers/summaries in conference/workshop proceedings, and 115 abstracts in conference/workshop proceedings. Author and subject indexes are provided.)

Chen, H.Y.H., (R. Arnup), (P. Henry), (J. Parton), (W.R. Watt), (N. Wood) and (G. Lucking). 2001. **Successional pathways: Proposed SFMM rules for northeast regional standard forest units**. Ont. Min. Nat. Resour., N.E. Sci. Technol., Timmins, ON. NEST Tech. Note No. TN-018.
(This note summarizes successional rules for new regional Standard Forest Units to be used with the Strategic Forest Management Model in the development of forest management plans in MNR's Northeast Region. (*Copies available from Northeast Science and Technology, South Porcupine.*))

Cherry, M. 2001. **Options for allocating afforestation stock in Ontario with anticipated climate change**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 148. 29 p.
(Afforestation involves the establishment of forests on previously unforested land. Important considerations include whether the species is adapted to the site being afforested and, more recently, the amount of carbon it will sequester over both the short and long term. Northwestern Ontario is expected to become warmer and drier over the next 50 years, with some species shifting eastwards. On dry sites, trembling aspen may exhibit the best growth but jack pine may also be a good choice. Where moisture is less limiting, white spruce and tamarack would be good choices for afforestation. In northeastern Ontario many species have high genetic variation and are suited to broad habitats. Some species in southern Ontario may be extirpated as ranges shift northwards. Species recommended for afforestation in this area include white pine, red maple, and green ash, which are expected to be less affected by climate change than some other species. While general suggestions for stock allocation can be made, more knowledge is needed to accurately predict species and population responses to changing climate.)

(Choi, J.), (C.G. Lorimer), (J. Vanderwerker), W.G. Cole and (G.L. Martin). 2001. **A crown model for simulating long-term stand and gap dynamics in northern hardwood forests**. For. Ecol. Manage. 152: 235-258.
(Evaluation of ecosystem management alternatives in forests will require new or revised models that

can simulate the development of multi-aged stands managed on long rotations and with unconventional stand structures. In this paper we describe the development and testing of an individual-tree, crown-based model (CANOPY) designed to simulate canopy gap dynamics and stand structural changes in mature and old-growth northern hardwood forests dominated by *Acer saccharum*. The model was calibrated with data from 63 plots in managed and unmanaged stands, with sample trees ranging in age from 17-311 years. For *A. saccharum*, $R^2$ values ranged from 0.76 to 0.81 for prediction of basal area increment, 0.45-0.50 for crown radial increment, and 0.63-0.79 for height increment. Equations using field-measured crown size and crown competition variables provided only slightly better predictions than conventional mensurational variables such as DBH and plot stocking level. Use of the model for long-term (250 year) projections of cumulative DBH and crown radius provided a good match to largely independent size-age trends in the database, but total height was moderately overestimated for trees more than 100 years old. Both the field data and simulations suggest that basal area increment of individual trees does not decline with age in these species but actually increases up to the observed maximum of 300 years, which is consistent with nearly linear diameter-age trends often reported for shade-tolerant species. Lateral crown growth of trees with exposed crown margins, however, showed curvilinear decreasing trends with age. These findings suggest that the common assumption of constant radial closure of canopy gaps by border trees could potentially overestimate rates of gap closure and underestimate the probability of successful gap capture by saplings in multi-aged stands.)

Colombo, S.J. 2001. **Climate change and forest impacts**. Pp. 46-53 *in* Impacts and Adaptation to Climate Change: Developing an Ontario Node of a National C-CIARN Network. Klassen, J. and H. Auld, eds. Environ. Can - Ont. Reg., Ottawa, ON.
(This presentation summary discusses the relationship between climate change and forests in terms of vegetation, disturbance, carbon management, and timber supply and highlights some of the forest-related climate change work underway in MNR.)

Colombo, S.J., (M.J. Menzies) and (C. O'Reilly). 2001. **Influence of nursery cultural practices on cold hardiness of coniferous forest tree seedlings**. Pp. 223-252 *in* Conifer Cold Hardiness. Bigras, F.J. and S.J. Colombo, eds. Kluwer Academic Publ., Dordrecht, NL.
(This chapter reviews conifer seedling nursery practices that affect cessation of seedling physiology including growth, timing of terminal bud induction, rate and final extent of cold hardening, and measures used to protect conifer seedlings in nurseries from damaging freezing temperatures.)

Colombo, S.J., P.H. Sampson, (C.W.G. Templeton), (T.C. McDonough), (P.A. Menes), D. DeYoe and (S.C. Grossnickle). 2001. **Assessment of nursery stock quality in Ontario**. Pp. 307-323 *in* Regenerating the Canadian Forest: Principles and Practice for Ontario. Wagner, R.G. and S.J. Colombo, eds. Fitzhenry and Whiteside, Ltd., Markham, ON. 650 p.
(This chapter discusses types of seedling quality assessment tests available, and their timing, use, and future in Ontario.)

(Dey, D.C.) and G.B. MacDonald. 2001. **Overstory manipulation**. Pp. 157-175 *in* Regenerating the Canadian Forest: Principles and Practice for Ontario. Wagner, R.G. and S.J. Colombo, eds. Fitzhenry and Whiteside, Ltd., Markham, ON. 650 p.
(The regeneration environment is strongly influenced by forest overstory and pattern and intensity of harvest. This chapter discusses the effects of harvesting-related changes in overstory density on light intensity, air and soil temperature, and soil moisture.)

(Fang, J.), (A. Chen), C. Peng, (S. Zhao) and (L. Ci). 2001. **Changes in forest biomass carbon storage in China between 1949 and 1998**. Science 292:2320-2322.
(The location and mechanisms responsible for the carbon sink in northern mid-latitude lands are uncertain. Here we used an improved estimation method of forest biomass and a 50-year national forest resource inventory in China to estimate changes in the storage of living biomass between 1949 and 1998. Our results suggest that Chinese forests released about 0.68 petagram of carbon between 1949 and 1980, for an annual emission rate of 0.022 petagram. Carbon storage increased significantly after the late 1970s, mainly due to forest expansion and regrowth. Since the mid-1970s, planted forests have sequestered 0.45 petagram of carbon and their average carbon density increased from 15.3 to 31.1 megagrams per hectare, while natural forests have lost an additional 0.14 petagram carbon, suggesting that carbon sequestration through forest management practices addressed in the Kyoto Protocol could help offset industrial carbon dioxide emissions.)

(Fang, J.), (S. Piao), (Z. Tang), C. Peng and (W. Ji). 2001. **Interannual variability in net primary production and precipitation**. Science 293:1723a.
(This note features technical comments on a climate

change article that appeared in an earlier issue of Science that found the opposite for the relationship between annual precipitation and normalized difference vegetation index in North America of what Fang et al. found in China.)

(Grossnickle, S.C.), W.C. Parker, (T.J. Blake) and (R.F. Sutton). 2001. **Ecophysiological principles**. Pp. 91-118 *in* Regenerating the Canadian Forest: Principles and Practice for Ontario. Wagner, R.G. and S.J. Colombo, eds. Fitzhenry and Whiteside, Ltd., Markham, ON. 650 p.
(Ecophysiology is the physiological response of plants to fluctuations in their environment. Understanding plant response to environment is essential to both planning and improving forest regeneration. Primary physiological response processes of plants discussed in this chapter include water relations, gas exchange, mineral nutrition, tolerance to freezing, dormancy, and morphological development. Major environmental influences on seedlings and how these influence seedling physiology and responses are also examined.)

(Guiot, J.), (I.C. Prentice), C. Peng, (D. Jolly), (F.Laarif) and (B. Smith). 2001. **Reconstructing and modelling past changes in terrestrial primary productivity**. Pp. 479-498 *in* Terrestrial Global Productivity. Saugier, B., J. Roy and H.A. Mooney, eds. Academic Press, New York, NY.
(This chapter discusses potential ways to reconstruct past global net primary productivity using data and models.)

(Hopkin, A.A.), S. Greifenhagen and (J. Holland). 2001. **Decay, stains, and beetles in ice-storm-damaged forests: A review**. For. Chron. 77(4): 605-611.
(A potential long-term threat to ice-damaged forests exists from decays, stains, and wood-boring insects. Damage to large branches or to the main stem can result in heartwood decay, particularly in older or less healthy trees. However, in branch stubs with a diameter of less than 7.5 cm, decay progresses to only a limited degree. Stem damage is not usual after ice storms. However, sunscald is common in sugar maple stands with damaged crowns, sometimes resulting in infection by the sap rot fungus *Cerrena unicolor*. Fungi of the genera *Ophiostoma*, *Ceratocystis* and *Ceratocystiopsis* (blue stains) can cause significant staining to standing timber in damaged softwood stands; however, these fungi do not cause structural damage. Bark beetles (Scolytidae) and wood-borers (Buprestidae and Cerambycidae), which attack damaged trees in northeastern North America are normally secondary invaders. However, thinning of the canopy from ice damage could cause increased infestation by these insects.)

(Jayaraman, K.) and W.T. Zakrzewski. 2001. **Practical approaches to calibrating height-diameter relationships for natural sugar maple stands in Ontario**. For. Ecol. Manage. 148: 169-177.
(The efficiency of a random parameter approach for calibrating a height-diameter model of natural sugar maple in Ontario was compared with that of a fixed parameter approach. From a practical point of view, both methods were equally efficient. However, the random parameter model has a theoretical advantage, mostly because random deviations from the mean function can be predicted with known precision levels. The study also produced parameter estimates that can be used for localizing height-diameter curves in natural undisturbed sugar maple stands in southern Ontario. The models had negligible bias. The root mean square of the residuals for tree height, computed for an independent validation data set, was in the order of 1.5 m. The coefficient of determination for the validation data set was 0.95.)

(Kelso, J.R.M.), (R.J. Steedman), (J.M. Gunn), (K.E. Smokorowski), (N.P. Lester), W.G. Cole, (C.K. Minns) and (K.H. Mills). 2001. **A framework for the advancement of aquatic science -- Lake habitat experiments as an example**. Aquat. Ecosyst. Health Manage. 4:453-461.
(Resource managers must often act to protect fisheries and fish habitat without the certainty that their actions are justified. Delivering the science needed to support and direct management decisions is a daunting exercise, likely beyond the capabilities of a single research group or management entity. This problem is exacerbated by the lack of a common framework to formulate and test important hypotheses about biotic response to aquatic habitat change. A partial solution may be provided by cooperative research networks to produce an integrated design and synthesis of quasi-independent studies within a common framework for hypothesis generation and testing. We demonstrate such an approach by using it to test hypotheses about lake fish community response to habitat change. Our framework includes a list of hyptheses, a list of treatments, an experimental design specifying the number of lakes per treatment, and advice for measuring habitat and fish parameters. Because our procedure uses before-after comparisons to measure effects of habitat changes, lakes can be studied independently yet still contribute synergistically to the larger experiment.)

Lautenschlager, R.A. 2001. **Ice storm 1998 -- Forest policy and research papers**. For. Chron. 77(4): 597.
(Introduction and overview of ice damage-related policy research papers appearing in this special issue of the Forestry Chronicle. Papers emanated from a

workshop held in Ottawa, Ontario in October 2000 to share results of 3 years of post-ice storm research results.)

Lautenschlager, R.A. 2001. **Science and certification**. For. Chron. 77(1): 151-152.
(An argument for including the best available science information in certification principles and criteria for sustainable forest management. Herbicides and alternatives are used as an example.)

Lautenschlager, R.A. and (D. Voigt). 2001. **Effects of forest regeneration practices on wildlife**. Pp. 521-540 *in* Regenerating the Canadian Forest: Principles and Practice for Ontario. (Wagner, R. G. and S.J. Colombo, eds. Fitzhenry and Whiteside, Ltd., Markham, ON. 650 p.
(This chapter provides an overview of basic wildlife biology, and discusses the forest as wildlife habitat as well as the effects of forest regeneration on wildlife.)

Lautenschlager, R.A. and J.A. Winters. 2001. **Quantifying ice damage by counting branches on damaged sugar maple trees**. For. Chron. 77(4): 637-642.
(We quantified the productive capacity of sugar maple crowns by counting branches (third order and epicormic) on damaged trees following the 1998 ice storm in southeastern Ontario. The covariates derived from branch counts provided greater statistical confidence for explaining post-damage root starch and sap (volume and sweetness) production than did crown damage estimates. When combined with predictive equations for leaf area and biomass per branch, branch counts produce estimates of foliar biomass for individual trees, regardless of the amount of damage received. Although visual estimates of crown damage seem appropriate for documenting stand-level injury, those interested in individual tree responses or comparing damage among trees should consider counting branches as a way to quantify the productive capacity of trees with or without damage.)

(Lin, H.) and C. Peng. 2001. **The role of raster pixel size and shape in geographic information system**. Remote Sens. Info. 61(1): 21-23.
(This paper discusses the relationship between data volume and pixel size in raster data structure and attempts to find a pixel shape that is better than the current grid shape for raster data accuracy. Overall a hexagon shape provided the best accuracy at the least cost in this analysis.)

Lu, P. 2001. **Genetic parameter estimation and breeding value prediction of black spruce in the new Wabigoon breeding zone**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. Unpubl. Int. Rep. 108 p.
(This report provides background information and data for 18-year-old black spruce progeny tests in northwestern Ontario. Findings included survival rates of 72 to 85%. Progeny tests were affected by within-block environmental variation, which was reduced by post-blocking techniques during analysis. Family mean height growth and survival were highly correlated with faster-growing families surviving better. Individual and family heritability estimates ranged from 0.08 to 0.15 and 0.34 to 0.51, respectively, which is comparable to results from other progeny tests reported in Ontario. Estimated genetic gains for height were 6.27 and 7.03% for main and elite breeding populations, respectively. *(Internal report not for general distribution).)*

(Maki, D.S.) and S.J. Colombo. 2001. **Early detection of the effects of warm storage on conifer seedlings using physiological tests**. For. Ecol. Manage. 153: 237-249.
(Four species of conifer seedlings were more tolerant of pre-planting within-package warm storage than suggested by the literature and seedling physiology tests were highly predictive of incipient damage and growth potential. Bareroot white pine, red pine, white spruce, and black spruce seedlings in sealed polyethylene bags were stored at 15°C from 5 to 13 days or at 30°C from 12h to 4 days. Seedling performance potential was evaluated after warm storage based on height increment, survival, and foliar damage in a 7-week greenhouse growth trial. White pine, white spruce, and black spruce seedlings were unaffected by storage at 15°C storage for up to 13 days, whereas red pine tolerated up to 5 days storage at 15°C without damage or loss of growth. Red pine, black spruce, and white spruce could tolerate at least 12h storage at 30°C with no appreciable loss of performance potential while white pine suffered impairment even with the shortest period of storage (12h) at 30°C. The survival and growth of seedlings was accurately predicted by within-package ethanol concentration, shoot tip electrolyte leakage, chlorophyll fluorescence, and root growth potential.)

McLaughlin, J.A. 2001. **Distribution, hosts, and site relationships of *Armillaria* spp. in central and southern Ontario**. Can. J. For. Res. 31: 1481-1490.
(This study investigated the species, geographic distribution, host range, site relationships, and impacts of *Armillaria* root disease in central and southern Ontario. Rhizomorphs and infected wood samples were collected at 110 of 111 sites. Six species were identified by polymerase chain reaction or diploid-haploid pairings. *Armillaria gallica* was most commonly isolated and had the broadest host range. It was seldom isolated from conifers but

often from oaks. It was most often found on moist sites and showed strong preference for calcareous soils. *Armillaria calvescens* was rarely isolated from conifers but often from maples, where it commonly caused butt rot. It was found most often on coarse loamy or fine, well-drained, fresh sites. *Armillaria ostoyae* had the second broadest host range. It was seldom found on sugar maple but dominated on conifers, especially on dry-fresh, rapidly drained sandy to coarse loamy sites. It was not found on sites with finer soils. *Armillaria sinapina* and *Armillaria gemina* were found in more northerly parts of the study area on noncalcareous sites. *Armillaria sinapina* often caused butt rot and was often found on poorly drained sites. *Armillaria gemina* was found only on hardwoods. *Armillaria mellea* was found on dead hardwoods at 4 locations.)

McLaughlin, J. A. 2001. **Impact of Armillaria root disease on succession in red pine plantations in southern Ontario**. For. Chron. 77(3): 519-524.
(Armillaria root disease created openings in southern Ontario red pine plantations that are gradually succeeding to hardwood-dominated mixedwoods through natural regeneration. A study of 13 root disease centres found several tree and shrub species colonizing the openings. Black cherry was the most important hardwood and white pine the most important conifer colonizer. Mortality of black cherry and white pine regeneration was greater than for other species. Long-term survival of conifers in the centres is doubtful, and high mortality of black cherry is expected. Other hardwood species may fare better but with growth and yield losses due to Armillaria infection.)

Mohammed, G.H. 2001. **Recommendations for sustainable development of non-timber forest products**. Pp. 116-120 *in* Forest Communities in the Third Millenium: Linking Research, Business, and Policy Toward a Sustainable Non-timber Forest Product Sector. Kenora, ON, 1-4 Oct. 1999. USDA For. Serv., North Central Res. Stn., Gen. Tech. Rep. NC-217. 151 p.
(A recent study of non-timber forest products (NTFPs) in Ontario identified at least 50 types of NTFPs and hundreds of specific products used for food, health and personal care, materials and manufacturing, environmental purposes, landscape and gardening, and aesthetics. Recommendations for advancing the NTFP sector in a sustainable fashion include emphasizing value-added products, using waste material for new products, coordinating collection of NTFPs with timber harvest and tending operations, emphasizing rural and community-based NTFP opportunities, developing methods for cultivating NTFP species, and increasing coordination within government and between government, public, and private stakeholders.)

Mohammed, G.H., (G.R. McLeod), (P.A. Menes) and (V.R. Timmer). 2001. **Bareroot stock production**. Pp. 265-279 *in* Regenerating the Canadian Forest: Principles and Practice for Ontario. Wagner, R.G. and S.J. Colombo, eds. Fitzhenry and Whiteside, Ltd., Markham, ON. 650 p.
(This chapter discusses the types of bareroot nursery stock produced in Ontario and the general stages of stock production.)

Noland, T.L., (G.H. Mohammed) and N.H. Seymour. 2001. **An improved fluorescein diacetate seed viability test for jack pine, black spruce, and white spruce**. Seed Sci. Technol. 29: 509-516.
(Changes to improve the FDA test were slicing the seedcoats prior to soaking in the stain, increasing the FDA stain concentration from 0.2% to 2.0% and adding a 45-minute incubation period (after the FDA stain soak) to the procedure. The improved FDA test estimated seed lot viability to within +/- 5 for most seedlots of the 3 species and to within +/- 10 for the remainder. Visual numerical ratings used to estimate embryo viability for the FDA test were highly correlated with the amount of extractable fluorescein found in jack pine embryos. The results suggest that the FDA test is an alternative viability test for jack pine, black spruce, and white spruce seed.)

Noland, T.L., G.H. Mohammed and (R.G. Wagner). 2001. **Morphological characteristics associated with tolerance to competition from herbaceous vegetation for seedlings of jack pine, black spruce, and white pine**. New For. 21: 199-215.
(Tolerance of bareroot and container-grown seedlings of black spruce, jack pine, and eastern white pine to competition from herbaceous vegetation was examined in the first 5 years after planting on a site in the Great Lakes-St. Lawrence forest of Ontario, Canada. Shoot and root morphological characteristics of various stocktypes were measured before planting and correlated with 5-year survival and growth following control and no control of herbaceous vegetation. For black spruce and jack pine, medium bareroot stocktypes had greater relative 5-year stem volume growth in the presence of herbaceous vegetation than did container stock of either species or large bareroot stock of spruce. Relative volume growth was measured as the ratio of the cumulative stem volume increment in the presence of vegetation (Veg) to that in the absence of vegetation (NoVeg), i.e., the Veg:NoVeg ratio. In white pine, the Veg:NoVeg ratio of volume increment of medium container and large bareroot stocktypes exceeded that of small container and medium bareroot stocktypes. In jack pine, root collar diameter at planting and number

of first-order lateral roots were positively correlated with 5-year Veg:NoVeg ratio of volume increment. In white pine, the Veg:NoVeg ratio was also positively correlated with root collar diameter at planting and with root volume. In black spruce, the ratio was not related to pre-plant morphology. Thus, for white pine and jack pine, certain pre-plant morphological features may be useful in forecasting the relative ability of different stocktypes to grow under herbaceous competition conditions in the field.)

Noland, T.L., (K.R. Creasey) and (B.S.P. Wang). 2001. **Seed management**. Pp. 243-263 *in* Regenerating the Canadian Forest: Principles and Practice for Ontario. Wagner, R.G. and S.J. Colombo, eds. Fitzhenry and Whiteside, Ltd., Markham, ON. 650 p.
(A basic understanding of seed biology is critical for successful forest regeneration. This chapter discusses seed biology, and seed collecting, processing, and testing methods.)

Obenchain, A.M. (ed.). 2001. **Insights**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. 5(1): 12 p.
(This issue of OFRI's newsletter highlights white pine regeneration projects, Ontario's forest fire history CD, partnerships with forest industry, a boreal mixedwood project update, and a Tomentosus guide.)

Obenchain, A. M. 2001. **OFRI's research greenhouses: growing better forests for Ontario**. Greenhouse Canada December: 22-27.
(This article provides an overview of OFRI's facilities and how they are used by forest researchers. Highlights of some of the research projects that are currently using the growth facilities include a white pine blister rust resistance project, germination experiments, and a study on genetic resistance to hypoxylon canker in aspen. )

(Olthof, I.), (D.J. King) and R.A. Lautenschlager. 2001. **Leaf area index change in ice storm-damaged sugar maple stands**. For. Chron. 77(4): 627-635.
(Changes in leaf area index (LAI) between the summers of 1999 and 2000 were measured using the TRAC optical instrument in sugar maple stands damaged by the 1998 ice storm. Changes were determined to be significant if they were greater than the 95% bounds of the instrument's precision. They were evaluated in relation to 1998 canopy damage estimates. 1999 stand treatments (lime, fertilizer, lime + fertilizer, herbicide, none), and 1999 understory vegetation cover. Results show that LAI change is significantly related to overstory damage, and understory abundance in the 0 to 7 m height range. Plot treatments were not related to these LAI changes, possibly due to the short time interval between application and LAI measurement.)

Papadopol, C. 2001. **Tree plantations recycle wastewater safely**. Water Wastewater Int. 16(2): 30-31.
(Recycling municipal wastewater poses increasingly serious challenges to communities. Specialized fast-growing plantations that require water and nutrients provide an efficient and inexpensive way to recycle effluent outside the food chain. A software package has been developed for operating this recycling system on the basis of weather and soil conditions. It calculates daily effluent irrigation levels for a hybrid poplar plantation based on atmospheric demand for evapotranspiration each day, reducing the risk of deep infiltration. This article describes the system, some best practices, and potential uses.)

Parker, B. and B. Brown. 2001. **Using fire hose to protect microclimate station electrical cables in forest research**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Note No. 60. 4 p.
(This note summarizes the advantages of using surplus fire hose to protect electrical cables in research trials involving microclimate stations. A case study example is provided that compares the traditional burying approach to the fire hose method.)

Parker, W.C., (K.A. Elliott), (D.C. Dey), (E. Boysen) and (S.G. Newmaster). 2001. **Managing succession in conifer plantations: Converting young red pine (*Pinus resinosa* Ait.) plantations to native forest types by thinning and underplanting**. For. Chron. 77(4): 721-734.
(The effects of thinning on growth and survival of white pine, white ash, and red oak, and understory plant diversity were examined in a young red pine plantation. Five years after thinning, seedling diameter, height, and stem volume were positively correlated with thinning intensity and the size of canopy openings. Percent survival did not differ among thinning treatments, but was significantly higher in white ash and white pine than red oak. Understory vegetation included 113 species, with species richness increasing with thinning intensity and proximity to neighbouring plant communities. Thinning to create relatively large canopy openings, in combination with underplanting, can promote the natural succession of young pine plantations to native forest species.)

(Paterson, J.), D. DeYoe, (S. Millson) and (R. Galloway). 2001. **Handling and planting of seedlings**. Pp. 325-341 *in* Regenerating the Canadian Forest: Principles and Practice for Ontario. Wagner, R.G. and S.J. Colombo, eds. Fitzhenry and Whiteside, Ltd., Markham, ON. 650 p.

(This chapter describes the procedures for handling and planting nursery stock so as to help prevent stress, strain, and eventual injury that could reduce survival or growth.)

Peng, C., (J. Liu), (Q. Dang), (X. Zhou) and (M.J. Apps). 2001. **Modelling complex forest ecosystems: A hybrid model simulation approach.** Pp. 125-138 *in* Proc. Forest Modelling for Ecosystem Management, Forest Certification, and Sustainable Management. LeMay, V. and P. Marshall, ed. Vancouver, BC, 12-17 Aug. 2001. Faculty of Forestry, Univ. British Columbia, Vancouver, BC.
(In this paper, a hybrid, monthly-time-step model of forest growth and carbon dynamics (namely TRIPLEX) is presented. The TRIPLEX model integrates the forest production model of 3-PG, the forest growth and yield model of TREEDYN3.0 and the soil-carbon-nitrogen model of CENTURY4.0. It is designed to be a hybrid of empirical and process-based models that can be used for forest management (e.g., growth and yield prediction), carbon budget, and climate change impact assessments. TRIPLEX was tested against age-dependent growth measurements from 12 permanent sample plots (PSP) in jack pine stands in northern Ontario. Comparisons of simulated stand growth variables (e.g., tree diameter, height, and stem density) with those observed in PSPs indicated good agreement over 30 years. Simulated tree total volume and aboveground biomass are within the range expected for these plots. The model shows promise but some future modifications are recommended.)

Peng, C., (L. Zhang) and (J. Liu). 2001. **Developing and validating nonlinear height-diameter models for major tree species of Ontario's boreal forests**. North. J. Appl. For. 18(3): 87-94.
(Six commonly used nonlinear growth functions were fitted to individual tree height-diameter data of 9 major tree species in Ontario's boreal forests. Data for 22,571 trees were collected from new permanent sample plots across the northeast and northwest of Ontario. Available data for each species were split into 2 sets: the majority (90%) were used to estimate model parameters; the remaining data (10%) were reserved to validate the models. Performance of the models was compared and evaluated by model, $r^2$, mean difference, and mean absolute difference. Results showed that these 6 sigmoidal models captured the height-diameter relationships and fit the data equally well, but produced different asymptote estimates. Sigmoidal models such as Chapman-Richards, Weibull, and Schnute functions provided the most satisfactory height predictions. The effect of model performance on tree volume estimation was also investigated. Tree volumes of different species were computed by Honer's volume equations using a range of diameters and the predicted tree total height from the 6 models. For trees with less than 55 cm diameters, the height-diameter models produced very similar results for all species, while more differentiation among the models was observed for larger trees (diameters > 80 cm).)

Peng, C., (L. Zhang), (S. Huang), (X. Zhou), (J. Parton) and (M. Woods). 2001. **Developing ecoregion-based height-diameter models for jack pine and black spruce in Ontario**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Rep. No. 159. 10 p.
(Jack pine and black spruce are economically important, dominant tree species in Ontario. In this study, jack pine and black spruce individual tree height and diameter measurements were used to fit the Chapman-Richards growth function at provincial, regional, and ecoregional scales. Our results suggest that the height-diameter relationship of the species vary within a geographic region, depending on local climate, soil, and ecological conditions. Incorrect application of provincial or regional height-diameter models within ecoregions will result in inaccurate local tree height and volume estimates. These new ecoregion-based height-diameter models provide useful tools for resource managers faced with producing volume estimates for forest management-related decisions.)

Pinto, F.N.L., (C. Nelson), (B.J. Naylor) and (R.G. White). 2001. **Regeneration planning and prescription development.** Pp. 573-588 *in* Regenerating the Canadian Forest: Principles and Practice for Ontario. Wagner, R.G. and S.J. Colombo, eds. Fitzhenry and Whiteside, Ltd., Markham, ON. 650 p.
(This chapter summarizes how regeneration planning is incorporated into the planning hierarchy in Ontario. Provincial policy and land use plans set forest biodiversity goals, which are used to guide regeneration efforts at the forest level. Forest management plans are used to describe regeneration options for each vegetation community. Specific stand-level prescriptions outline treatments to be used in specific areas. Then individual project plans are developed to guide and evaluate operations such as tree marking, harvesting, site preparation, planting, and tending.)

(Pitt, D.), (D. Weingartner) and S. Greifenhagen. 2001. **Precommercial thinning of trembling aspen in northern Ontario: Part 2 - Interactions with Hypoxylon canker**. For. Chron. 77(5): 902-910.
(Hypoxylon canker incidence and associated mortality were monitored in 6 northern Ontario trembling aspen stands following precommercial thinning. At each

of the 6 sites, a randomized complete block design experiment was established with 4 replicates of 5 thinning levels (none, 2-, 3-, 4-, and 5-m spacing). At the time of thinning, 3 stands were 5 years old; the remaining were 10, 15, and 22. Over the 15- to 17-year observatoin period, Hypoxylon-related mortality increased 6 to 9%, regardless of thinning age or density. Hypoxylon infection incidence increased 2 to 6% in unthinned stands and 8 to 11% in thinned stands by year 15. No differences among thinning levels were observed. Hypoxylon-caused mortality was independent of tree size and canopy position. Mortality attributed to factors other than Hypoxylon was 31 to 44% in unthinned stands and 7 to 23% in thinned stands. Results suggest that log size and stand yield may be manipulated through density regulation, without concern for interacting effects associated with Hypoxylon canker. Models are provided for estimating disease losses so that predictions can be factored into future crop planning efforts.)

(Remmel, T.K.) and A.H. Perera. 2001. **Fire mapping in a northern boreal forest: Assessing AVHRR/NDVI methods of change detection**. For. Ecol. Manage. 152: 119-129.
(Understanding natural fire regimes is crucial to developing harvesting scenarios and conducting sustainable resource management in the boreal forest. To gain this understanding, resource professionals need efficient and cost-effective data collection methods that can operate over vast and isolated landscapes. We compared 3 Advanced Very High Resolution Radiometer (AVHRR)/Normalized Difference Vegetation Index (NDVI) methods of fire detection and mapping for a case study in northern Ontario, Canada, of the 1992, 1993, and 1995 fire seasons. Fire mapping accuracy was assessed by the spatial coincidence between mapped fires and ground-truthed information using a decision-tree approach and by testing the hypothesis that various calculated accuracy components were equal within an ANOVA design. Ground-truthed fire sizes and shapes were correlated with the AVHRR/NDVI-mapped areas; however, light cloud contamination increased false detection of fires due to NDVI suppression. The multiple threshold technique of change detection provided better estimates of fire areas than did single threshold methods.)

Rice, J.A, G.B. MacDonald and (D.H. Weingartner). 2001. **Precommercial thinning of trembling aspen in northern Ontario: Part 1 - Growth responses**. For. Chron. 77(5): 893-901.
(Trembling aspen use in Ontario has increased over the past 20 years. With this increased demand, stand conditions required for optimum growth are also of interest. This paper describes the results of an aspen thinning trial established in 1979 across the commercial range of aspen in Ontario. Six aspen stands aged 5 to 22 were thinned to residual spacings of 2 x 2 m, 3 x 3 m, 4 x 4 m, and 5 x 5 m. Unthinned and thinned plots were measured at regular intervals for up to 17 years after treatment. Diameter increased significantly with residual tree spacing over the range of site conditions, geographic locations, and tree ages. Height generaliy increased with increased residual spacing. Fifteen to 17 years after treatment, gross total volume was highest in unthinned plots for all 6 stands and decreased as residual spacing increased. Gross merchantable volume did not vary significantly with thinning in all but the oldest stand. Results of this study do not support the use of precommercial thinning to increase aspen fibre yield. However, if the management goal is maximizing individual tree growth, precommercial thinning of aspen is an option.)

(Robinson, D.E.), (R.G. Wagner), F.W. Bell and (C.J. Swanton). 2001. **Photosynthesis, nitrogen-use efficiency, and water-use efficiency of jack pine seedlings in competition with four boreal forest plant species**. Can. J. For. Res. 31(11): 2014-2025.
(This study was established to help understand the mechanism underlying nitrogen (N) and water competition between jack pine and 4 boreal forest competitor species. Large-leaved aster, Canada blue-joint grass, trembling aspen , and red raspberry were planted at a range of densities (0 to 8 plants per square metre) with jack pine seedlings. Net photosynthesis, nitrogen-use efficiency, and water-use efficiency of each species were monitored over 3 consecutive growing seasons. Changes in available soil N and water were also measured. Jack pine photosynthesis, nitrogen-use efficiency, and water-use efficiency decreased as competitor density increased, but these effects varied among species ($p < 0.001$) and over time ($p < 0.001$). The influence of density on jack pine *Pn* decreased over time for aster and blue-joint grass and increased over time for aspen and raspberry ($p < 0.001$). At most sample times, jack pine photosynthesis correlated with available soil N. In contrast, the correlation between jack pine photosynthesis and soil water was rarely significant.)

Sampson, P.H., (P.M. Treitz) and G.H. Mohammed. 2001. **Remote sensing of forest condition: An examination of scale, structure, and function**. Can. J. Remote Sens. 27(3): 232-246.
(Sustainable forest management requires objective measures of forest condition and productivity. To

develop these measures, this study is part of the Bioindicators project that explores the pattern and physiological condition of vegetation following forest disturbance using a physiological remote sensing approach. Disturbance was silvicultural practices (selection, shelterwood, and clearcut) in an overmature sugar maple forest in the Algoma Highlands near Sault Ste. Marie, Ontario. Since remote sensing data is scale-dependent, studies must be designed with some consideration of the spatial expression of the variable of interest. Variables investigated here include the aboveground organization of vegetation (structure), and the functional integrity or condition of the forest stand. In addition, application of a single, arbitrary spatial resolution is considered inappropriate to describe the pattern and physiological condition of these treatments. A Compact Airborne Spectrographic Imager (CASI) was flown at 3 altitudes (1000, 2000, and 3000 m) and the resulting data examined using semivariogram analysis. Range and sill parameters were derived from an analysis of overall scene variance using the first principal component (PCA), and from red-edge inflection point wavelength ($\grave{e}_p$) data. Spatial resolutions estimated from the range value of the semivariogram were approximately 9.0 and 5.0 m for the PCA and $\grave{e}_p$ data, respectively. Sill and range parameters were also correlated to critical forest parameters such as biomass, stocking, and crown area. Redundancy analysis (RDA) was used to examine relationship(s) between canopy reflectance and leaf-based measures (e.g., chlorophyll and pigment concentrations) and biophysical features (e.g., crown cover and biomass). Resulting RDA biplots uncovered a significant relationship between canopy opening and spectral indices. A discussion of the practical implications of our findings is presented.)

(Shropshire, C.), (R.G. Wagner), F.W. Bell and (C.J. Swanton). 2001. **Light attenuation by early successional plants of the boreal forest.** Can. J. For. Res. 31: 812-823.
(The influence of 8 early successional plant species from the boreal forest on photosynthetically active radiation (PAR) were compared using a controlled plant competition study. Four woody (green alder, upland willow, white birch, wild red raspberry) and four herbaceous (eastern bracken fern, Canada blue-joint grass, large-leaved aster, fireweed) plant species were studied using an additive density experiment with jack pine seedlings. The transmission of PAR through the plant canopies was measured using a line quantum sensor under 6 plant density treatments at the time of maximum canopy development each year. Four measures of plant abundance (planting density, actual density, projected leaf area index, and crown cover) were evaluated for their ability to predict PAR transmission through the plant canopies. Visual estimates of crown cover provided the best models each year. Vertical profiles of PAR transmission were used to compare the canopy structure among plant species and were used to refine the models. During the second growing season, increasing crown cover of blue-joint grass and large-leaved aster had the largest influence on PAR. In the third season, green alder, upland willow, and white birch (along with blue-joint grass and fireweed at the jack pine crown level) had the greatest influence on PAR. PAR measurements taken from a nearby forest for several of the plant species indicate that the models developed from our controlled experiment are reasonably applicable to naturally occurring plant populations.)

Ter-Mikaelian, M.T. and R.A. Lautenschlager. 2001. **Predictive equations for leaf area and biomass for sugar bushes in eastern Ontario.** For. Chron. 77(4): 643-649.
(In January 1998, an extensive ice storm caused severe damage to sugar bushes in eastern Ontario. Foliage biomass and foliage area estimates were required to assess effects of the ice storm and remedial treatments on variables related to sugar maple production. Equations were developed to predict leaf biomass of undamaged individual sugar maple trees in the ice-damaged area. Data were collected in early to mid-August 2000 in eastern Ontario. Basal diameter of all third-order branches of 22 trees from 2 stands was measured, along with tree DBH, total height, and height to the base of live crown. In addition, foliage was collected from 2 branches (one from the lower and one from the upper part of each tree crown). Samples were used to develop equations predicting leaf biomass (oven-dried weight) of individual branches from their basal diameter. These equations were applied to estimate total leaf biomass of individual trees, and the resulting estimates were used to develop equations predicting leaf biomass from DBH and the number of branches per tree. The resulting equations accounted for over 90% of the variation in leaf biomass of individual trees. Leaf biomass-DBH equations for the 2 stands were significantly different ($P < 0.0001$), while no significant difference was detected in the leaf biomass-number of branches equations ($P = 0.1573$).)

(Wagner, R.G.), F.W. Bell and (R.A. Campbell). 2001. **Vegetation management.** Pp. 431-457 *in* Regenerating the Canadian Forest: Principles and Practice for Ontario. Wagner, R.G. and S.J. Colombo, eds. Fitzhenry and Whiteside, Ltd., Markham, ON. 650 p.

(This chapter discusses the effects of competing vegetation on seedlings, tree responses to vegetation and vegetation management, and methods of managing competition in forest plantations.)

(Wagner, R.G.) and S.J. Colombo, eds.. 2001. **Regenerating the Canadian Forest: Principles and Practice for Ontario**. Fitzhenry and Whiteside, Ltd., Markham, ON. 650 p.
(This book is a comprehensive synthesis of the principles and practice of forest regeneration with special reference to Ontario. It covers a range of topics including the history of reforestation in Ontario, scientific principles, site preparation, seedling production and establishment, direct seeding and natural regeneration, stand tending and protection, as well as effects of forest regeneration on other forest resources such as wildlife and aquatics.) (*Not available from OFRI – order directly from publisher or distributor.)*

(Whitney, R.D.), S. Greifenhagen, J. McLaughlin, T. Meyer and (H.L. Gross). 2001. **Diseases and mycorrhizae**. Pp. 460-482 *in* Regenerating the Canadian Forest: Principles and Practice for Ontario. Wagner, R.G. and S.J. Colombo, eds. Fitzhenry and Whiteside, Ltd., Markham, ON. 650 p.
(This chapter presents information about preplantation diseases and their control, diseases in plantations and young forests, and mycorrhizae and their benefits.)

Yemshanov, D. and A.H. Perera. 2001. **Modelling boreal forest succession at broad scales: A North American bibliography**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf Pap. No. 146. 46 p.
(This bibliography contains over 600 citations describing existing knowledge on succession in North American boreal forests, and the current state-of-knowledge in modelling succession, emphasizing broad scales. References are grouped by geographic and taxonomic categories. Literature on theories and concepts of succession modelling, issues of scale in modelling succession, the spatial process of propagule dispersal, and probabilistic modelling of forest succession is also included.)

Zakrzewski, W.T. 2001. **TCM/PAM support tool for timber surveys: User's manual 2001**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. Unpubl. Rep. 31 p.
(TCM/PAM is a software tool intended to be used as part of timber surveys to estimate tree- or stand-level timber volume. This user's manual provides step-by-step guidance on using the software tool as well as some background about the sampling methods embedded in the software.)

(Zarco-Tejada, P. J.), (J.R. Miller), G.H. Mohammed, T.L.Noland and P.H. Sampson. 2001. **Estimation of chlorophyll fluorescence under natural illumination from hyperspectral data**. JAG 3(4): 321-327.
(This paper reports a series of laboratory and field measurements of spectral reflectance under artificial and natural light conditions which demonstrate that effects of natural chlorophyll fluorescence are observable in the reflectance red edge spectral region. These are results from the progress made to link physiologically-based indicators to optical indices from hyperspectral remote sensing in the *Bioindicators of Forest Sustainability Project*. This study is carried out on twelve sites of *Acer saccharum* M. in the Algoma Region, Ontario (Canada), where field measurements, laboratory simulation experiments, and hyperspectral CASI imagery have been carried out in 1997, 1998, 1999 and 2000 campaigns. Leaf samples from the study sites have been used for reflectance and transmittance measurements with the Li-Cor Model 1800 integrating sphere apparatus coupled to an Ocean Optics Model ST1000 fibre spectrometer in which the same leaves are illuminated alternatively with and without fluorescence-exciting radiation. A study of the diurnal change in leaf reflectance spectra, combined with fluorescence measurements with the PAM-2000 Fluorometer show that the difference spectra are consistent with observed diurnal changes in steady-state fluorescence. Small canopies of *Acer saccharum* M. have been used for laboratory measurements with the CASI hyperspectral sensor, and under natural light conditions with a fibre spectrometer in diurnal trials, in which the variation of measured reflectance is shown experimentally to be consistent with a fluorescence signature imposed on the inherent leaf reflectance signature. Such reflectance changes due to CF are measurable under natural illumination conditions, although airborne experiments with the CASI hyperspectral sensor produced promising but less convincing results in two diurnal experiments carried out in 1999 and 2000, where small variations of reflectance due to the effect of CF were observed.)

(Zarco-Tejada, P. J.), (J.R. Miller), T.L.Noland, G.H. Mohammed and P.H. Sampson. 2001. **Scaling-up and model inversion methods with narrowband optical indices for chlorophyll content estimation in closed forest canopies with hyperspectral data**. IEEE Transact. Geosci. Remote Sens. 39(7): 1491-1507.
(This study focussed on 12 sites of sugar maple in the Algoma region, Canada, where field measurements, laboratory simulation experiments, and hyperspectral

compact airborne spectrographic imager (CASI) imagery were acquired in 1997, 1998, and 1999. A different set of 14 sites of the same species were used for validation in 2000. Infinite reflectance and canopy reflectance models were used to link leaf to canopy levels through radiative transfer simulation. Study of the merit function in the numerical inversion showed that red edge optical indices used in the minimizing function perform better than when all single spectral reflectance channels from hyperspectral airborne CASI data are used, and the effect of shadows and LAI variation are minimized. Estimates of leaf pigment by hyperspectral remote sensing of closed forest canopies were feasible. Pigment estimations by model inversion as described in this paper using these red edge indices can in principle be readily transferred to the MERIS sensor.)

## Publications 2002

Baldwin, D.J.B., A.H. Perera, K. Weaver and D.H. Schroeder. 2002. **Multi-scale tools to assess spatial feasibility of intensive forest management**. *In* ESRI International User Conference 2002. San Diego, CA. 8-12 July 2002. 10 p.
(We assessed the spatial feasibility for intensifying forest management for a forest area over 8 million ha in Ontario Canada. All land use policies and regulations were translated into spatially explicit rules and applied as a hierarchical filter based on compiled forest inventory and values data. In addition, we modelled several landscape ecological processes to provide biological context to evaluate legally feasible areas. GIS-based decision support tools were developed to interactively analyze feasibility scenarios at both strategic (corporate, regional) and tactical (management-unit) levels. Here we describe data compilation challenges, spatial filter construction, development of software tools, and use of the results.)

Bell, F.W. and (S.G. Newmaster). 2002. **The effects of silvicultural disturbances on the diversity of seed-producing plants in the boreal mixedwood forest**. Can. J. For. Res. 32(7): 1180-1191.
(The practice of clear-cutting, followed by site preparing with mechanical equipment, planting a single tree species, and applying herbicides, has been cited as creating monocultures in northern forests. Research on a trembling aspen-dominated mixedwood provided an opportunity to examine the potential of silvicultural activities to (*i*) create monocultures, (*ii*) create opportunities for the establishment of exotic plant species, and (*iii*) result in the loss of indigenous plant species. Detailed botanical surveys were conducted for up to 5 years post-treatment in 4 clearcuts that were mechanically site prepared, planted with a single conifer species, and released with either motor-manual, mechanical, or herbicide treatment. Species richness, abundance (foliar cover), diversity indices, and rank abundance diagrams indicate that the treatments had immediate effects, but none created a monoculture during the period of study. We conclude that the use of clearcutting, mechanical site preparation, planting a single conifer species, followed by release with motor-manual cutting, mechanical cutting, or herbicide spraying, will not create monocultures in the conditions tested. While 37 exotic species were observed, none of them were tree or shrub species. In addition, no net loss of indigenous seed-producing plants was detected. Missed strips and patches, which accounted for up to 25% of the sampled area, buffered treatment effects.)

Buse, L.J. and A.H. Perera. (comp.). 2002. **Emulating natural forest landscape disturbances: Concepts and applications Popular summaries**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 149. 100 p.
(This information paper provides a compendium of summaries of presentations from a May 2002 symposium on emulating natural forest landscape disturbances (ENFD). The concepts, challenges, and potential consequences of implementing ENFD at the landscape level in forest management are discussed from several viewpoints. In addition, 10 case studies from across northern and central North America provide some practical applications of the concepts behind ENFD.)

Candau, J.-N. 2002. **Bioclimatic analysis of declining aspen stands in northeastern Ontario**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Rep. No. 154. 16 p.
(In 2000-2001, aspen decline was observed over large areas of northeastern Ontario. We analyzed the bioclimatic characteristics of the affected areas and suggest potential causes of the decline. The bioclimatic characteristics analyzed include forest tent caterpillar defoliation and drought history; forest composition, age, and structure; and soil quality. The decline areas experienced unusually frequent defoliation by forest tent caterpillar in the 10 years prior to the decline: 80% of the decline area has been defoliated more than 3 years since 1989. The spatial similarity between areas of high frequency of defoliation and decline areas suggests a strong relationship between the 2 factors. According to the Drought Code, used in this analysis to assess soil moisture in the decline areas, northeastern Ontario experienced significant drought in 1998. The combined effect of repeated defoliation and moisture-related stress could have caused the decline. In

addition, forest data indicate that most of the declining aspen stands were mature or overmature. This characteristic, combined with poor soil quality, could have precipitated the decline.)

Chen, H.Y.H., (P.V. Krestov) and (K. Klinka). 2002. **Trembling aspen site index in relation to environmental measures of site quality at two spatial scales**. Can. J. For. Res. 32(1): 112-119.
(To evaluate the variation in trembling aspen productivity at a large geographic scale, we examined relationships between site index and environmental factors from 142 even-aged, fully stocked stands on a variety of sites across interior British Columbia. Site index was derived from stem analysis and the environmental measures included climate surrogates (latitude, longitude, elevation), biogeoclimatic zone, slope– aspect, actual soil moisture regime (SMR), and soil nutrient regime (SNR). The spatial gradients, slope–aspect, SMR, and SNR affected aspen site index, but their relationships greatly varied with biogeoclimatic zone. At the provincial scale, these relationships were weaker than on the zonal scale. Among the models developed for predicting aspen site index, we recommend the zone-specific all-factor model, which explained 82% of the variation of site index and provided unbiased and precise predictions.)

Chen, H.Y.H. and (R. Popadiouk). 2002. **Dynamics of North American boreal mixedwoods**. Environ. Rev. 10 (3): 137-166.
(Boreal mixedwoods (BMWs) are the most productive and diverse forest ecosystems in North American boreal forests. A good understanding of BMW stand dynamics is a prerequisite for sustainable management of these vital resources. In this review, we describe the patterns and processes of BMWs created by natural disturbances, examine the biotic and abiotic factors that influence these patterns and processes, and discuss forest management implications related to stand development. Based on distinct structural and developmental features, BMW stand development is characterized by 4 stages: stand initiation, stem exclusion, canopy transition, and gap dynamics. These stages of stand development provide a conceptual model of complex developmental processes. However, multiple pathways are possible during BMW stand development depending on disturbances, neighbour effects, and stand condition. Boreal mixedwood management at the stand level needs to emulate the natural development process and target a specific stand structure and species composition. Alternative silvicultural techniques are available to achieve the multiple objectives of BMWs. Further considerations at various temporal and spatial scales and at the operational level are required to ensure sustainable BMW management.)

Cherry, M.L. and (Y.A. El-Kassaby). 2002. **Growth, morphology, and cold hardiness of yellow-cedar seedlings originating from an abbreviated reproductive cycle**. Can. J. For. Res. 32(1): 52-58.
(A common garden study investigated growth, morphology, and cold hardiness of yellow-cedar (*Chamaecyparis nootkatensis* (D. Don) Spach) seedlings originating from seed that had matured at an accelerated rate. This early maturing seed, produced at a low-elevation southern Vancouver Island seed orchard, was known to have similar germinability and seedling morphology as high-elevation normally maturing seeds. Population differences in 3-year-old seedlings were evident only in shoot harvest index (ratio of stem/shoot dry weight). The amount of stem elongation that occurred prior to the formation of secondary foliage (juvenile height) and harvest index were weakly correlated with source elevation at which maternal parents were developed. Traits that exhibited no discernable differences between progeny from early maturing seed and the control normally maturing seed included midwinter cold hardiness testing and selected measures of shoot morphology and growth. The control seedlings had significantly less height growth prior to the transition of primary foliage to secondary foliage formation than did the seedlings originating from early maturing seed.)

Colombo, S.J. and (S. Gellert). 2002. **Frost hardiness testing: An Ontario update**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Note No. 62. 4 p.
(This research note provides an overview of the importance of hardening tree seedlings for overwinter storage, and outlines methods used for testing seedling frost hardiness.)

(Dumas, M.T.) and J.A. McLaughlin. 2002. **Microbes inhabiting *Picea* wounds and their antagonism to *Haematostereum sanguinolentum***. Pp. 181-193 *in* Root and Butt Rots of Forest Trees. Proceedings of the IUFRO Working Party 7.02.01. G. Laflamme, J.A. Bérubé and G. Bussières, eds. Quebec City, QC, 16-22 Sept 2001. Nat. Resour. Can. - Can. For. Serv., Info. Rep. LAU-X-126.
(This paper summarizes a study comparing the establishment of microbes on wounds of black and white spruce in mixedwood stands subjected to partial cutting. Wounds inflicted when the average air temperature was above and below 0°C were evaluated over 8 months to determine if ambient temperature at the time of wounding influenced the diversity and establishment of pioneering microflora

on the wound surface. Wound size varied from 0.6 to 850.8 $cm^2$ with most wounds occurring on the root, stem, and butt, respectively. Pre-freeze up wounds had the highest level of biodiversity of microorganisms and *Pseudomonas* species comprised the greatest proportion of the populations on these wounds. Yeast species dominated the surface of wounds inflicted during the post-freeze-up period. Decay fungi were isolated more often from post-freeze-up wounds and *Poria rivulosa* was the most commonly isolated decay organism.)

(Fleming, R.A.), (H.J. Barclay) and J.-N. Candau. 2002. **Scaling-up an autoregressive time-series model (of spruce budworm population dynamics) changes its qualitative behaviour**. Ecol. Model. 149:127-142.
(The emergence of issues such as climate change has motivated the development of time-dependent models to forecast how plant and animal populations will react over large spatial extents. The consequences of scaling-up a linear, second-order, autoregressive, time series model of spruce budworm population dynamics on the model's predictions and on the interpretation of the model's output are considered. Such time series models have been proposed as templates for incorporating outbreak dynamics in the decision systems supporting forest insect management that are currently being adapted to climatic change problems. Analysis of the underlying deterministic component of the time series model showed that: (1) parameter estimates changed with the spatial resolution-parameter values estimated from time series data consisting of large area averages were negatively correlated ($r$=-0.931, $P$<0.0005) and as much as 40 or 50 times greater in absolute value than the parameters generating the fine resolution data from sampling sites 1600 times smaller in extent. (2) Even the qualitative nature of the dynamics appeared to change in response to scaling-up. The long cycle, converging oscillations generated at fine resolutions gave way to 5 additional types of qualitative behaviour at coarser resolutions including various types of divergent behaviour and non-oscillating behaviour. (3) The amount of distortion involved in scaling-up depends on the model's degree of non-linearity and on the fine scale spatial variation in population densities. An approach to correcting for such distortion is outlined. The potential consequences of scaling-up deserve consideration whenever data measured at different spatial resolutions are integrated during model development, as often happens in climate change research.)

(Fleming, R.A.), J.-N. Candau and (R.S. McAlpine). 2002. **Landscape-scale analysis of interactions between insect defoliation and forest fire in central Canada**. Clim. Change 55(1-2): 251-272.
(Analysis of Ontario's historical records from 1941–1996 showed that spruce budworm caused whole tree mortality within $389\times10^3$ $km^2$. This amounted to 9.2% of the annual cumulative area with moderate to severe defoliation. Large (>2 $km^2$) fires were reported in approximately 65,000 $km^2$ and overlapped only 2.8% of the area of reported spruce budworm (SBW)-caused tree mortality. Within the $417\times10^3$ $km^2$ defoliated by SBW at least once in 1941–1996, the maximum total area recorded as defoliated in any year was over 20 times the maximal area burnt. In the 19,950 $km^2$ experiencing both wildfire and SBW defoliation, analysis of the spectra of time lags between the two disturbance types indicated that fires occurred 3 to 9 years after a SBW outbreak disproportionately often. This 'window of opportunity' for wildfire varies geographically: it starts later after SBW outbreak and lasts longer in western than in eastern Ontario. In addition, 7.5% of the areas containing SBW killed trees were burnt in western compared to 4.8% in eastern Ontario. These geographical differences may result at least partly from slower decomposition of dead fuels in the drier climates of the western SBW belt compared to the eastern SBW belt. The implications for climatic change are discussed.)

(Guyette, R.P.), W.G. Cole, (D.C. Dey) and (R.-M. Muzika). 2002. **Perspectives on the age and distribution of large wood in riparian carbon pools**. Can. J. Fish. Aquat. Sci. 59(3): 578-585.
(Most knowledge of carbon budgets is derived from the productivity and sequestration of carbon in terrestrial and marine ecosystems. Less is known of carbon stored in riparian areas associated with lakes and rivers. Case studies of the age distribution of carbon in aquatic large wood ($C_{lw}$) from 2 landscapes with different drainage patterns were established using tree-ring and $^{14}C$ dating. Cumulative negative exponential distributions of the age of $C_{lw}$ ranged over periods from 1000 to 9485 years. Large woody debris had mean residence times of 261 years in small oligotrophic lakes and 350–800 years in a stream reach. Large wood can reside for an order of magnitude longer in freshwater–riparian ecosystems than in comparable aboveground terrestrial ecosystems. Although riparian areas make up only a small fraction of most landscapes, they may account for a relatively larger proportion of aged $C_{lw}$ than is stored aboveground in terrestrial ecosystems.)

(Jiang, H.), (M.J. Apps), C. Peng, (Y. Zhang) and (J. Liu). 2002. **Modelling the influence of harvesting on Chinese boreal forest carbon dynamics**. For. Ecol. Manage. 169(1): 65-82.

(Chinese boreal forests, in the Daxinganling Mountains of northeastern China, are the most southern part of the global boreal forest biome. The dominant species is larch (*Larix gmelinii*) with other major species including birch (*Betula platyphylla*), pine (*Pinus sylvestris* var. *mongolica*), and oak (*Quercus mongolica*). In this study, the terrestrial ecosystem process model CENTURY 4.0 was used to investigate the influence of different harvest disturbance regimes on the carbon stocks and fluxes of Chinese boreal forest ecosystems relative to a natural disturbance regime. Managed disturbance regime scenarios examined include harvesting intensity (no biomass removal (NBR), conventional harvesting (CH) and whole tree harvesting (WTH)) and rotation length (from 30 to 400 years). Field data were assembled from 3 forest regions (Xinlin, Tahe, Mohe), representing the northern, middle, and southern parts of the Chinese boreal forest, respectively. Results indicate that biomass, litter, and soil carbon stocks (averaged over a rotation period) can be elevated significantly by suppression of all disturbances (NBR scenario) but are lowest under the most intense harvest scenarios (WTH). Harvest rotation length had a significant influence on carbon stocks (biomass, litter and soil carbon); the lowest simulated carbon stocks were found with the shortest rotations, and relatively higher stocks under longer rotations. Net primary production (NPP) decreased with increasing harvest intensity or decreasing rotation length. Net ecosystem production (NEP) decreased with decreasing harvest intensity or decreasing rotation length. NPP and NEP reach maximum values at rotation lengths of about 200 and 100 years, respectively. Observations and simulated data for ecosystem carbon stocks (biomass, litter, and soil carbon) and carbon fluxes (NPP and NEP) in the southern region were slightly higher than those in the mid- and northern regions. The high productivity and biomass of the Chinese boreal forests relative to those of Canada, USA, and Russia, are likely due to their southerly location: warm temperatures and adequate precipitation create good conditions for forest development and growth. Nevertheless, the long history of forest use has resulted in much of the boreal forest in China's landscape being degraded.)

(Joyce, D.G.), P. Lu and R.W. Sinclair. 2002. **Genetic variation in height growth among populations of eastern white pine (*Pinus strobus*) in Ontario**. Silvae Genet. 51(4): 136-142.
(Provenances of eastern white pine were sampled from natural populations in Ontario and assessed in a 2-year greenhouse study followed by 2 5-year short-term field tests to reveal the scale and patterns of genetic variation in growth and adaptation at early ages. Results indicate that considerable genetic variation in growth potential exists among white pine populations in Ontario and that appreciable genetic gain can be realized through seed source selection in reforestation programs. Strong age-age correlation between growth traits at different years and the weak genotype-by-provenance interaction suggested high efficiency in provenance selection at early stages. Due to the latitude predominated clinal pattern of geographic variation and the significant reduction in growth potential when seeds are transferred from north to south, seed sources from less than 1.5 to 2.0 degrees (latitude) north of the area to be regenerated are recommended. Because of the relatively mild test environments at 2 sites and the short-term nature of this study, further research is required to investigate differences in cold hardiness among provenances before safe south to north seed transfer distances can be determined.)

Lautenschlager, R.A. and (T.P. Sullivan). 2002. **Effects of herbicide treatments on biotic components in regenerating northern forests**. For. Chron. 78(5): 695-731.
(We reviewed literature, primarily since 1990, that documents effects of herbicide treatments on major biotic components in northern forested ecosystems. Vegetation changes are responsible for changes in all other biotic components. Non-conifer vegetation is commonly reduced for 2 to 5 years following broadcast herbicide treatments. Fungal components, however, seem relatively unaffected. Short-term vegetation reductions in cover, density, and related biomass, if they occur, are species and/or vegetation group specific; longer-term changes are linked to conifer stocking, site quality, and the ability of conifers to dominate treated sites. Herbicide treatments do not reduce, and may increase, stand- and landscape-level plant species richness. Those treatments seldom produce monocultures when used by foresters for boreal or boreal mixedwood management. The active ingredients in the herbicide products used in forestry in northern ecosystems have no direct effect on the general health (survival, growth, reproduction) of animals in treated areas. Specific, stand-level forest management practices, particularly effects of site preparation and conifer release, must be examined in relation to the landscape mosaic and the desired future forest conditions. At broad scales, across boreal and boreal mixedwood ecosystems, conifers have been consistently replaced by hardwoods since Europeans began harvesting timber from those ecosystems. Herbicides provide a safe, effective tool for restoring conifers in previously conifer-dominated ecosystems. Forest scientists presently have a reasonable understanding of effects of a

variety of herbicide treatments on conifer growth and a variety of environmental components. However, they need to continually update that understanding relative to changing treatments (replicates, chemicals, combinations, or timing).)

(Liu, J.), C. Peng, (M. Apps), (Q. Dang), (E. Banfield) and (W. Kurz). 2002. **Historic carbon budgets of Ontario's forest ecosystems**. For. Ecol. Manage. 169(1): 103-104.
(Carbon (C) budgets of Ontario's forest ecosystems for the period 1920-1990 were calculated using the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS2). Results show that total forest biomass C in Ontario increased from 1.83 Pg ($10^{15}$g) to 2.56 Pg between 1920 and 1970, then decreased to 1.70 Pg by 1990. Carbon in soil and forest floor dead organic matter (DOM) increased from 8.30 to 11.00 Pg between 1920 and 1985 but decreased to 10.95 Pg by 1990. Ontario's forest ecosystems acted as a C sink sequestering 41-74 Tg ($10^{12}$g) C per year from 1920 to 1975, but became a C source releasing 7-32 Tg C per year (5-year average) after 1975. Disturbances (fire, insects, harvesting) enhanced both direct and indirect C emissions, and also affected average forest age and C sequestration. Net primary production (NPP), net ecosystem production (NEP), and net biome production (NBP) were affected by both disturbances and average forest age. Forests in the boreal (BO, 62.66 M ha), cool temperate (CT, 7.77 M ha) and moderate temperate (MT, 0.20 M ha) regions had different C dynamics. However, boreal forests dominated Ontario's forest C budget because of the large area and associated C stock. Detailed C budgets for 1990 were also analyzed. The average forest ages in 1990 were 36.2 years for BO, 43.4 years for CT, and 92.1 years for MT regions, respectively. The total C stock of Ontario's forest ecosystems (excluding peatlands) was estimated to be 12.65 Pg, including 1.70 Pg in living biomass and 10.95 Pg in DOM and soil. Average C density was 179 Mg ha$^{-1}$ (101 for biomass and 155 Mg ha$^{-1}$ for DOM and soil). The total net C balance (excluding harvest removal) was 31.8 Tg. NPP, NEP, and NBP were 267.6, 28.2, and 40.6 Tg per year, respectively. The young age (36.2) of Ontario's boreal forests indicates a great potential for C sequestration and storage. Roughly 1 Pg C could be sequestered with a 10-year increase in forest age. A less severe disturbance regime and/or higher NPP would convert Ontario's forest ecosystems back to a C sink.)

(Liu, J.), C. Peng, (Q. Dang), (M. Apps) and (H. Jiang). 2002. **A component object model strategy for reusing ecosystem models**. Comp. Electron. Agric. 35(1): 17-33.
(One way to effectively reuse existing ecosystem models is to break them into smaller functional parts. These parts are then reconstructed into standardized model components that can be pieced together to form a new model with desired characteristics. TRIPLEX is a flexible and customizable prototype model for forest ecosystem simulation that was constructed using 3 existing models: 3-PG, TREEDYN3, and CENTURY 4.0. Well-established parts of these models were rebuilt as component model objects. These components can be intregrated via a user interface to form a customized new model. Model developers from different modelling environments can easily reuse these objects. TRIPLEX also supports component overload, where 2 or more components with the same or a similar role in the customized model can work together, which further increases model flexibility.)

(Maki, D.) and S. Colombo. 2002. **The physiology of shipping for spring and summer planting: Vulnerability of seedlings to stress in different shipping systems**. Pp. 9-12 *in* LUSTR Coop Annual Meeting and Workshop 2001 -- Working Together for Our Common Future. Timmins, ON, 19-21 Feb 2001. LUSTR Coop.
(This is a brief summary of a presentation that covered the potential stress events inherent in various tree seedling shipping systems and the likeliness that shipping systems will affect the physiological quality of tree seedlings. Mitigating actions for the various storage/shipping scenarios are provided.)

(Mallik, A.U.), F.W. Bell and (Y. Yanli Gong). 2002. **Effectiveness of delayed brush cutting and herbicide treatments for vegetation control in a seven-year-old jack pine plantation in northwestern Ontario, Canada**. Silva Fenn. 36(2): 505–519.
(Efficacy of 3 conifer release treatments, (1) single application of glyphosate (Vision™) herbicide, (2) multiple application of glyphosate herbicide, and (3) motor-manual brush cutting for controlling competing plants, particularly trembling aspen, pin cherry, green alder, and beaked hazel, was studied in a 7-year-old jack pine plantation in northwestern Ontario, Canada. The single and multiple glyphosate applications were equally effective in controlling trembling aspen and pin cherry, causing over 90% stem mortality. The brushsaw treatment caused an initial decrease followed by an increase in stem density of both species. A high degree of stem thinning by natural mortality in the untreated control plots was observed in trembling aspen (23–46%) and pin cherry (41–69%) over 4 years. As with trembling aspen and pin cherry, stem density of green alder and beaked hazel

initially decreased and then increased following the brushsaw treatment, mainly due to resprouting. Stem mortality in green alder and beaked hazel was 45% and 97%, respectively, 2 years after the operational glyphosate treatment. Competition index (CI) was low (mean CI = 52, ranging from 18 to 115) in all the plots including the untreated control. A significant increase in basal diameter of jack pine in the brushsaw and herbicide-treated plots compared to the control was apparent 3 years after the treatments. Jack pine seedlings in the brushsaw- and glyphosate-treated plots were taller compared to that of control but differences were not significant. Lower species richness and diversity were recorded in the herbicide-treated plots compared to the brushsaw and control plots in the third growing season following treatment.)

McPherson, S., (S. Strobl) and (R. Spence). 2002. **Efficacy of the EZJECT lance for releasing red oak from sugar maple competition.** Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Note No. 61. 4 p.
(This note describes early results of a vegetation management study to test the efficacy of seasonal EZJECT treatments for controlling sugar maple of various diameters to increase red oak survival and growth. Late fall treatments on maple stems less than 10 cm diameter were most effective. Alternative treatments may be required for larger stems.)

(Mihail, J.D.), (J.N. Bruhn), T.R. Meyer and F.W. Bell. 2002. **Pine needle rust effect on *Pinus banksiana* in response to interspecific plant competition and telial host density**. Can. J. For. Res. 32(8): 1372-1380.
(Three compartments differing in soil texture were established in 1994 to examine interspecific competition using *Pinus banksiana* Lamb. and 11 competitive species including *Aster macrophyllus* L. Each competitive species was established in six planting densities in combination with *P. banksiana*. Since *P. banksiana* and *A. macrophyllus* are hosts of the pine needle rust (PNR) fungus, *Coleosporium asterum* (Diet.) Syd., conditions were inadvertently created for examining the effect of PNR on tree growth under interspecific competition. Tree size was measured in 1995 and 1996. PNR was assessed in 1996 (incidence) and 1997 (severity). *Pinus banksiana* root collar diameter, stem length, and crown diameter were significantly lower in the loam soil texture compartment compared with the clay or sand compartments. Using the same metrics, *P. banksiana* size was reduced as competitor density increased in 1995 and 1996, particularly for *A. macrophyllus*. Further, *P. banksiana* size was significantly reduced by PNR infection in 1996. Excluding the plots with *A. macrophyllus*, *P. banksiana* infected in 1996 were significantly larger than disease-free trees in the clay and sand compartments, suggesting that larger trees may represent larger targets for spore deposition. In 1996, PNR incidence was significantly correlated with proximity to *A. macrophyllus* plots.)

(Mohammed, G.H.) 2002. **Forest genetics and tree improvement in Ontario: Synopsis of a science workshop**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 151. 13 p.
(This report provides a summary of presentations from a forest genetics and tree improvement workshop hosted by OFRI's forest genetics program in June 2002. It provides an overview of the role of tree improvement in promoting forest productivity, some principles and techniques used in tree improvement programs, new technologies, and an indication of where tree improvement programs in Ontario are headed.)

Morneault, A.E. et al. 2002. **Some ecological effects of shelterwood harvesting and site preparation in white pine forests**. Ont. Min. Nat. Resour., For. Res. Devel. Sect., Sault Ste. Marie, ON. Fact sheets 2 p.
(A series of 12 fact sheets was produced on each component of the white pine shelterwood project by project partners. Fact sheet topics include: site description, study design, and treatments; growth and survival of planted white pine; natural regeneration; plant diversity; red-backed salamanders; carabid beetles; downed woody debris; soil fertility and planted white pine growth and nutrient conditions; microclimate; genetic diversity; emergence, growth, and survival of seeded white pine; white pine seed production, characteristics and dispersal patterns.)

(Newmaster, S.G.) and F.W. Bell. 2002. **The effects of silvicultural disturbances on cryptogam diversity in the boreal mixedwood forest**. Can. J. For. Res. 32(1): 38-51.
(In northern forests, cryptogams (spore-producing plants) occupy a key position in forest ecosystem diversity and function. Forest harvesting and silvicultural practices have the potential to reduce cryptogam diversity. This project used 4 blocks that were mechanically site prepared, planted with a single conifer species, and subsequently subjected to 5 conifer release treatments: (1) motor-manual cleaning, (2) mechanical brush cutting, (3) aerial application of triclopyr, (4) aerial application of glyphosate, and (5) control (untreated clearcut). Five 10 × 10 m subplots were installed in each of the 5 treatment plots and the uncut forest on the 4 blocks. Botanical surveys were conducted before and 1 to 5 years after treatments. Species richness and abundance, Shannon's and Heip's indices, and rank

abundance diagrams clearly show that richness and abundance were affected by silvicultural treatments. Vegetation management treatments resulted in significant reductions in cryptogam diversity, to the point that only a few colonists and drought-tolerant species remained. Cryptogam diversity was ranked in the following order: forest > clearcut > mechanical clearing > herbicide treatment. Herbicide treatments had the greatest initial effect on species richness, species abundance, and diversity indices. Cryptogam diversity showed signs of recovery 5 years after treatments. Missed strips (untreated areas) within clearcuts provided a refuge for remnant communities of forest cryptogams that could help to rehabilitate forest diversity.)

Obenchain, A.M. (ed.). 2002. **Insights**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. 5(2): 12 p.
(This issue of OFRI's newsletter includes an update on vegetation management projects, Armillaria research, managing succession in red pine plantations, soil water research, using fire hose in microclimate research, and information about the recently published *Regenerating the Canadian Forest* book.)

(Panigada, C.), (J.R. Miller), (M. Meroni), T. Noland, (M. Boschetti), (R. Colombo), (C.M. Marino) and M. Packalen. 2002. **Preliminary pigment retrieval results from a sparse-canopy poplar plantation in northern Italy using hyperspectral data**. *In* 1st Intern. Symp.: Recent Advances in Quantitative Remote Sensing, Valencia, Spain, 16-20 Sept. 2002. University of Valencia, 5 p.
(Successful retrieval of leaf pigment content in closed forest canopies is only recently being reported. Nevertheless, forestry continues to pose significant challenges to quantitative biochemical variable retrieval due to problmes associated with the structural complexity in common open canopies, conifer canopies, or sparse canopies. This research was focussed on a poplar plantation in northern Italy where hyperspectral data were acquired in summer 2001 by different airborne hyperspectral sesnsors: DAIS (digital airborne imaging spectrometer) and ROSIS (reflective optics system imaging spectrometer). The approach investigated to predict chlorophyll content from the airborne hyperspectral data is the numerical inversion of canopy and leaf reflectance models coupled. The ecological properties of the poplar plantation, characterized by low leaf area index values, open and sparse canopy and an accompanying presence of a thick layer of understory vegetation, represents a challenging issue to the application of simple canopy modelling for interpretation. In this study we evaluated the influence of understory vegetation on biochemical constituent estimation by inversion of a simple ratio optical index through a comparison of the overstory leaf pigment retrieval results from a poplar stand area in which understory was harvested, before the sensor overpass, relative to the non-tilled part of the poplar stand.)

Peng, C., (H. Jiang), (M.J. Apps) and (Y. Zhang). 2002. **Effects of harvesting regimes on carbon and nitrogen dynamics of boreal forests in central Canada: a process model simulation**. Ecol. Model. 155(2): 177-189.
(The effects of different harvesting intensities and rotation lengths on the long-term carbon (C) and nitrogen (N) dynamics of boreal forests in central Canada were simulated using the process-based ecosystem model CENTURY 4.0. Three harvesting intensities and 4 rotation lengths were investigated. Results suggest that intensive harvesting regimes (e.g., whole-tree harvesting (WTH)) would decrease total ecosystem C, soil C storage, and N availability, compared with conventional harvesting (CH). Harvested biomass would increase with increasing harvesting intensity. Net loss of forest productivity (indicated by aboveground biomass) would be higher in more productive stands in the low boreal ecoclimatic region. For a given harvesting intensity, total ecosystem C stock and N availability would be highest with long rotations (120 years) and reduced under shorter rotations (60 and 30 years). Extremely short rotations (i.e., 30 years) would reduce boreal forest productivity by as much as 65%. Longer rotations and less intensive harvesting could increase C sequestration 36 to 40% in the boreal forest region of central Canada.)

Peng, C., (J. Liu), (Q. Dang), (M.J. Apps) and (H. Jiang). 2002. **TRIPLEX: A generic hybrid model for predicting forest growth and carbon and nitrogen dynamics**. Ecol. Model. 153(1): 109-130.
(This paper describes the testing of a hybrid, monthly time-step model of forest growth and carbon dynamics (TRIPLEX). The model integrates the forest production model of 3-PG, the forest growth and yield model of TREENYD3, and the soil-carbon-nitrogen model of CENTURY4.0. The model is intended to be comprehensive without becoming complex, and minimizes the number of input parameters required, while capturing key processes and important interactions between the carbon and nitrogen cycles of forest ecosystems. It is designed as a hybrid of both empirical and mechanistic components that can be used for (1) making forest management decisions (e.g., growth and yield prediction), (2) quantifying forest carbon budgets, and (3) assessing the effects of climate change in both the short and long term. We tested TRIPLEX against age-dependent

growth measurements from 12 permanent sample plots (PSP) in jack pine stands in northern Ontario (Canada). Comparisons of simulated stand growth variables (e.g., tree diameter, height, and stem density) with those observed in PSPs indicated good agreement over 30 years. Predictions of tree total volume and aboveground biomass were within the expected range for these plots. While the model is promising, future modifications are discussed.)

Peng, C., (J. Liu), (Q Dang), (X. Zhou) and (M. Apps). 2002. **Developing carbon-based ecological indicators to monitor sustainability of Ontario's forests**. Ecol. Indic. 1(4): 235-246.
(With 2% of the world's forests and 17% of Canada's forested land, Ontario plays a major role in maintaining Canada's forests and managing them sustainably. Ontario is developing a set of criteria and indicators of sustainable forest management (SFM) to aid in conservation and sustainable management of its temperate and boreal forests. The criteria and indicators are intended to provide a framework for describing and assessing processes of SFM at a regional scale; and to improve the information available to the public and decision-makers. This paper describes three ecological indicators, evaluated using a carbon (C) budget model, a forest inventory database, and disturbance records to assess long-term sustainability of Ontario's forest ecosystems based on the environmental conditions of the past 70 years. Results suggest that total net primary productivity (NPP) of Ontario's forest ecosystems increased from 1925 to 1975 and then decreased between 1975 and 1990; Ontario's forest ecosystems acted as a C sink between 1920 and 1980, and a C source from 1981 to 1990, mainly due to decreased average forest age and NPP caused by increased ecosystem disturbance (e.g., fire, insect and disease infestations, harvesting) since 1975. Current estimates from this analysis suggest significant potential for Ontario's forests to function as C sinks by reducing ecosystem disturbances and increasing growth and storage of C in young forests.)

Perera, A.H., D. Yemshanov, F. Schnekenburger, D.J.B. Baldwin, K. Weaver and (D. Boychuk). 2002. **Spatial simulation of the large-scale forest fire regime in a boreal landscape**. Pp. 75-77 *in* Emulating Natural Forest Landscape Disturbances: Concepts and Applications Popular Summaries. Buse, L. J. and A. H. Perera, comp. Sault Ste. Marie, ON, 11-16 May 2002. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 149. 100 p.
(This presentation summary describes a mechanistic simulation model, the Boreal Forest Landscape Dynamics Simulator, that can be used to spatially predict the medium-term fire regime for the boreal biome of Canada.)

Perera, A.H. and L.J. Buse. 2002. **Emulating natural forest landscape disturbances: Overview and context**. Pp. 11-13 *in* Emulating Natural Forest Landscape Disturbances: Concepts and Applications Popular Summaries. Buse, L. J. and A. H. Perera, comp. Sault Ste. Marie, ON, 11-16 May 2002. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 149. 100 p.
(This overview sets the stage for an international symposium organized to scrutinize the concept of emulating natural forest landscape disturbances, its scientific foundation, and its feasibility.)

Pinto, F. and (S.M. Romaniuk). 2002. **Presettlement forest cover in northeastern Ontario**. Pp. 59-61 *in* Emulating Natural Forest Landscape Disturbances: Concepts and Applications Popular Summaries. Buse, L. J. and A. H. Perera, comp. Sault Ste. Marie, ON, 11-16 May 2002. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 149. 100 p.
(This presentation summary provides preliminary results of a reconstruction of presettlement vegetation for 9 forest management units in northeastern Ontario using primarily land surveyor notes.)

(Pouliot, D.A.), (D.J. King), F.W. Bell and (D.G. Pitt). 2002. **Automated tree crown detection and delineation in high-resolution digital camera imagery of coniferous forest regeneration**. Remote Sens. Environ. 82(3): 322-334.
(Remote sensing techniques provide a potentially low-cost alternative to field-based assessment of forest regeneration, but require the development of methods to easily and accurately extract the required information. Automated tree detection and delineation algorithms may be an effective means to accomplish this task. In this study, a tree detection-delineation algorithm designed specifically for high-resolution digital imagery of 6-year-old trees is presented and rigorously evaluated. The algorithm is based on analysis of local transects extending outward from a potential tree apex. The crown boundary is estimated using the point of maximum rate of change in the transect data and a rule base is applied to ensure that the point is contextually suitable. This transect approach is implemented in both the tree-detection and crown-delineation phases. The tree-detection algorithm refines the results of an initial local maximum filter by providing an outline for each detected tree and retaining only one local maximum value within this outline. The crown-delineation algorithm is similar to the detection

algorithm, but applies a different rule set in creating a more detailed crown outline. Results show that the algorithm's tree-detection accuracy was better than that using commonly applied fixed-window local maximum filters; it achieved a best result of 91%. For the crown-delineation algorithm, measured diameters from delineated crowns were within 17.9% of field measurements of diameter at the crown base on an individual tree basis and within 3% when averaged for the study. Tests of image pixel spacings from 5 to 30 cm showed that tree-detection accuracy was stable except at the lowest (30 cm) resolution where errors were unacceptable. Delineated crown-diameter accuracy was more sensitive to image resolution, decreasing consistently and nonlinearly with increasing pixel spacing. These results highlight the need for very high resolution imagery in automated object-based analysis of forest regeneration.)

Remmel, T.K. and A.H. Perera. 2002. **Accuracy of discontinuous binary surfaces: A case study using boreal forest fires.** Int. J. Geogr. Inf. Sci. 16(3): 287-298.
(Confidence in the conclusions of GIS and remote sensing analyses depends on our ability to specify their accuracy. The square error matrix, which is commonly used for accuracy assessment when the database contains continuous digital chloropleth data, allows computation of user's, producer's, overall, and Kappa coefficient accuracy values. However, when the underlying assumptions of the square error matrix method are violated, these accuracy values may become unreliable. We demonstrate how traditional forms of accuracy assessment can fail for discontinuous binary surfaces and provide an improved spatial assessment method. We developed 15 new accuracy measures that allow analysts to assess scene- and feature-level accuracy from many new perspectives.)

Schnekenburger, F., A.H. Perera, D. Yemshanoff and K. Weaver. 2002. **Design and implementation of a forest landscape dynamics simulator**. *In Proceedings* 2002 Summer Computer Simulation Conference. San Diego, CA, 14-18 July 2002. The Society for Modeling and Simulation International.
(BFOLDS is a boreal forest landscape dynamics simulator that models forest fire regimes and succession. It is a stochastic, spatially explicit, raster-based, event driven model, capable of simulating large landscapes (up to 10 M ha) over long time frames (up to 300 years), at a spatial resolution of 1 ha and temporal resolutions that vary with the process being modeled. BFOLDS is written in C++. Extensive use is made of the object-oriented features of the language including classes, inheritance, and polymorphism. Several language features simplified design and development, including template classes and functions, and operator overloading. Additionally, BFOLDS utilizes several data structures and algorithms provided in the C++ Standard Template Library, including lists, vectors, and multimaps. Choice of data structure had a significant impact on performance and memory requirements. This paper profiles some of the design and implementation choices used in BFOLDS.)

Schroeder, D. and A.H. Perera. 2002. **A comparison of large-scale spatial vegetation patterns following clearcuts and fires in Ontario's boreal forests**. For. Ecol. Manage. 159(3): 217-230.
(We examined spatial patterns of forest cover in a 4-decade series of post-fire and post-clearcut landscapes in boreal Canada. A suite of indices was used to quantify spatial patterns of post-disturbance vegetation, based on Landsat TM imagery and edaphic conditions. Landscape indices were grouped in terms of patch geometry, contagion, and composition. We used a general linear model to compare the effects of disturbance type, time since disturbance, edaphic conditions, and their interactions, on these indices. Clearcuts produced more heterogeneous landscapes after disturbances in comparison to fires. Time since disturbance also had a significant effect on spatial patterns of vegetation: the older disturbances had more landcover types with higher interspersion. Edaphic conditions also significantly affected spatial patterns of vegetation. Landscapes with complex spatial patterns of edaphic conditions also had complex spatial patterns of vegetation.)

(Suffling, R.) and A.H. Perera. 2002. **Concepts and approaches in predicting natural forest landscape disturbances**. Pp. 19-21 *in* Emulating Natural Forest Landscape Disturbances: Concepts and Applications Popular Summaries. Buse, L. J. and A. H. Perera, comp. Sault Ste. Marie, ON, 11-16 May 2002. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 149. 100 p.
(This presentation summary discusses what is natural with reference to concept of emulating natural disturbance and some of the approaches for characterizing and predicting disturbance regimes.)

Vasiliauskas, S. and H.Y.H. Chen. 2002. **How long do trees take to reach breast height after fire in northeastern Ontario?** Can. J. For. Res. 32(10): 1889-1892.
(Accurate determination of stand establishment ages is important in developing growth and yield models and in studying stand dynamics of fire-origin stands. The study objective was to determine time to reach

breast height for black spruce, jack pine, trembling aspen, and white birch from fire-origin stands under different site conditions in northeastern Ontario. Stands were randomly selected from burns with known fire dates. In each stand, 3 to 6 dominant and codominant trees of a selected species were cored at breast height (1.3 m above the ground level) to determine time to reach breast height. Trembling aspen and white birch did not differ for time to reach breast height after fire, taking 6 or 7 years, jack pine took marginally longer (8 years), whereas black spruce took the longest (18 years). While time to reach breast height did not vary among site conditions as described by soil texture and moisture regime, it was positively related to time since fire. The results of this study indicate that stand establishment dates and total tree ages can be substantially underestimated if breast height age is used as the stand age, resulting in misinterpretations of growth and yield and forest succession.)

(Wang, X.L.), (K. Klinka), H.Y.H. Chen and (L. de Montigny). 2002. **Root structure of western hemlock and western redcedar in single- and mixed-species stands**. Can. J. For. Res. 32(6): 997-1004.
(Root structure of western hemlock and western redcedar was studied in single- and mixed-species stands in Capilano River watershed, University of British Columbia Malcolm Knapp Research Forest, and Mission, southern coastal British Columbia. We sampled roots using a tree-to-tree trench excavation method. In each stand, roots were collected from 3 randomly located trenches using a 20 × 20 × 10 cm template along (*i*) a soil depth gradient: forest floor (FF), 0 to 10 cm (MS1), and 10 to 20 cm mineral soil layers (MS2) and (*ii*) a lateral soil gradient (tree-to-tree trenches). Hemlock–redcedar mixtures had the greatest root density, followed by pure hemlock and redcedar stands. In both pure hemlock stands and hemlock-redcedar mixtures, root density of all size classes (fine, medium, and coarse roots) decreased with increasing soil depth, whereas that of pure redcedar stands peaked at the MS1 layer. Density of roots along the lateral gradient varied among stand types and root size classes. Density of coarse roots was higher towards tree stems, while that of fine and medium roots was more evenly distributed. In the forest floor of the hemlock–redcedar mixtures, root density of all except redcedar coarse roots was not related to the distance to stems, but fine root density of hemlock was greater than that of redcedar. The highest root density in the hemlock–redcedar mixtures may indicate the presence of overlapping and intermingling roots and intense competition for available soil resources.)

Yemshanov, D. and A.H. Perera. 2002. **Early recruitment of tree species: a knowledge gap in landscape dynamics modelling**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 150. 22 p.
(We discuss ways to link existing knowledge of seed dispersal and early recruitment of boreal tree species into coarse-scale landscape models, as presented in the published literature, based on a review of the most important parameters controlling seed dispersal and early recruitment in boreal forest trees; a summary of spatial variables required to simulate important processes of seed dispersal and early recruitment in coarse-scale landscape models; and discussion of how these variables interrelate with spatial data used in existing coarse-scale forest landscape models. Future research needs are also identified.)

Yemshanov, D. and A.H. Perera. 2002. **A spatially explicit stochastic model to simulate boreal forest cover transitions: general structure and properties**. Ecol. Model. 150(2): 189-209.
(We describe a spatially explicit simulation model of large-scale forest cover transition in the North American boreal biome. This model is a time-dependent Markov chain with discrete states corresponding to dominant tree species in the forest canopy. To parameterize the model, we used 3 temporal variables, extracted from published data from field studies: period of persistence of a given cover type, the time interval of forest cover replacement by another, and the time of complete replacement. Environmental domains based on climate, soil moisture regime, and soil nutrient status stratified all forest cover transitions. Probability matrices of forest cover transition were derived for 15 discrete states at 20-year intervals for each of the environmental domains. Five spatial databases from boreal North America were used as input to the model: forest cover composition, time since last forest cover change, climate zone, soil moisture regime, and soil nutrient status. The model output consists of spatially explicit prediction of (a) time since last disturbance, (b) transition age, (c) forest cover composition, and (d) canopy age in 20-year time steps at 1 ha resolution. As a case study, we simulated forest cover transition in a 3.7 million ha area in boreal Canada. These 200-year simulations show that spatio-temporal transition of forest cover type is significant even in the absence of catastrophic disturbances.)

(Zarco-Tejada, P.J.), (J.R. Miller), (G.H. Mohammed), T.L. Noland and (P.H. Sampson). 2002. **Vegetation stress detection through chlorophyll a +**

**b estimation and fluorescence effects on hyperspectral imagery**. J. Environ. Qual. 31(5): 1433-1441.
(Physical principles applied to remote sensing data are key to successfully quantifying vegetation physiological condition from the study of the light interaction with the canopy under observation. We used the fluorescence–reflectance–transmittance (FRT) and PROSPECT leaf models to simulate reflectance as a function of leaf biochemical and fluorescence variables. A series of laboratory measurements of spectral reflectance at leaf and canopy levels and a modelling study were conducted, demonstrating that effects of chlorophyll fluorescence (CF) can be detected by remote sensing. The coupled FRT and PROSPECT model enabled CF and chlorophyll *a* + *b* ($C_{a+b}$) content to be estimated by inversion. Laboratory measurements of leaf reflectance (*r*) and transmittance (*t*) from leaves with constant $C_{a+b}$ allowed the study of CF effects on specific fluorescence-sensitive indices calculated in the Photosystem I (PS-I) and Photosystem II (PS-II) optical region, such as the curvature index (CUR). Dark-adapted and steady-state fluorescence measurements, such as the ratio of variable to maximal fluorescence ($F_v/F_m$), steady state maximal fluorescence ($F_m$), steady state fluorescence ($F_t$), and the effective quantum yield ($+F/F_m$) are acurately estimated by inverting the FRT–PROSPECT model. A double peak in the derivative reflectance (DR) was related to increased CF and $C_{a+b}$ concentration. These results were consistent with imagery collected with a compact airborne spectrographic imager (CASI) sensor from sites of sugar maple of high and low stress conditions, showing a double peak on canopy derivative reflectance in the red-edge spectral region. We developed a derivative chlorophyll index (DCI, calculated as $D_{705}/D_{722}$), a function of the combined effects of CF and $C_{a+b}$ content, and used it to detect vegetation stress.)

(Zarco-Tejada, P.J.), (J.R. Miller), (J. Harron), (B. Hu), T.L. Noland, (N. Goel), (G.H. Mohammed) and P.H. Sampson. 2002. **Chlorophyll a+b content estimation through turbid-medium and Monte-Carlo RT model inversion for forest canopies using hyperspectral data**. *In* 2001 AVIRIS Workshop. California Inst. Technol., JPL Publ. 02-1. 6 p.
(This paper reports on progress made within the Bioindicators of Forest Sustainability Project to develop links between physiologically based bioindicators from field and laboratory data and optical indices from hyperspectral remote sensing data for assessing forest condition.)

(Zhang, L.), C. Peng, (S. Huang) and (X Zhou). 2002. **Development and evaluation of ecoregion-based jack pine height-diameter models for Ontario**. For. Chron. 78(4): 530-538.
(The Chapman-Richards growth function is used to model jack pine tree height-diameter relationships at provincial, regional, and ecoregional levels. Results suggest that the tree height-diameter relationships of jack pine are significantly different among geographic regions of Ontario, depending on local climatic, soil, and ecological conditions. In light of this study, provincial and regional height-diameter models are not appropriate for predicting tree heights at the ecoregional level. Further, applying a specific ecoregional model to other ecoregions will significantly bias local tree height predictions. The ecoregion-based height-diameter models developed in this study may provide more accurate information on tree growth and development to forest resource managers and planners.)

## Publications 2003

Bell, F.W. 2003. **Intensive forest management science partnership: NEBIE plot network**. Pp. 141-143 *in* Meeting Emerging Ecological, Economic, and Social Challenges in the Great Lakes Region: Popular Summaries. Buse, L.J. and A.H. Perera, comp. Sault Ste. Marie, ON, 9-11 June 2003. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 155. 206 p.
(This popular summary reports the establishment, locations, data to be collected and partners of a province-wide intensive forest management study located across 8 forest types in Ontario.)

Bell, F.W. 2003. **Intensive forest management science partnership: NEBIE plot network**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. Fact Sheet. (Aussi disponible en francais.). 2 p.
(This fact sheet provides a summary of a project comparing the effects of a range of silvicultural intensities (natural, extensive, basic, intensive, and elite) on boreal and Great Lakes forests. Installation sets, forest cover, silvicultural intensities, treatments and project partners are listed. (*Updated annually*))

Buse, L.J. 2003. ***Science Matters*: Integrating MNR Forest Research and Policy -- summary of presentations and discussions**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. Int. Rep. 35 p.
(This report summarizes the presentations, outcomes, and evaluations of the *Science Matters: Integrating MNR Forest Research and Policy* event held in Sault Ste. Marie November 25, 2003. The objectives for

this one-day session were to (1) profile MNR's forest business drivers and policy issues, (2) profile ongoing CNFER and OFRI research projects, (3) encourage participants to get to know more of their colleagues, and (4) stimulate thinking and dialogue about how forest policy and research staff can more effectively integrate their efforts at all levels of the organization. What was very clear in both the research and policy presentations, and to some extent in the discussions, is that science is important both as a driver and in supporting MNR's policy development. MNR also clearly values and is committed to supporting its internal science capacity because of the value of longer-term research linked to corporate priorities and the opportunities for synergy within the organization. However, this integration requires ongoing effort by all levels of the organization, and room for improvement remains. For example, all staff need to make a conscious and consistent effort to work together as effectively as possible; to remain aware of current corporate issues and priorities; to be sensitive to the differences in various parts of the organization in terms of time scales and pressures; and to ensure that research and science initiatives are focused on MNR priorities, that results are delivered in an understandable and accessible form, and that their relevancy is periodically reviewed.)

Buse, L.J. and A.H. Perera. (comp.). 2003. **Meeting emerging ecological, economic, and social challenges in the Great Lakes region: Popular summaries**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 155. 206 p.

(Here we provide a compendium of summaries of the concurrent session and poster presentations from the June 2003 Great Lakes Forest Alliance's *Second Annual Sustainable Forest Management Summit: Meeting Emerging Ecological, Economic, and Social Challenges* held in Sault Ste. Marie, Ontario, Canada. The goal of the summit was to provide a broad forum to critically discuss emerging forest resource issues in the Great Lakes Region and a venue for natural resource professionals and stakeholders to exchange views and network on sustainable forestry issues. Topics include economic issues such as certification, criteria and indicators of sustainability, and value-added forest products; social issues such as environmental education, involving private landowners in developing strategies for sustainable forest management, and sustainable use; as well as ecological issues such as climate change, riparian zone management, and maintaining wildlife habitat.)

Chapman, K.A., S.J. Colombo, (L.D. Challen) and (S.Y. Zhang). 2003. **Tree instability in jack pine plantations**. Pp. 151-153 *in* Meeting Emerging Ecological, Economic, and Social Challenges in the Great Lakes Region: Popular Summaries. Buse, L. J. and A.H. Perera, comp. Sault Ste. Marie, ON. 9-11 June 2003. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 155. 206 p.

(Poor root form can lead to tree instability that results in stem form defects, especially in jack pine plantations. This popular summary present results from a survey of seedling root forms grown for one season in various container types.)

Cherry, M. and (W.H. Parker). 2003. **Utilization of genetically improved stock to increase carbon sequestration**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Rep. No. 160. 15 p.

(This report summarizes the results of a range wide white spruce provenance trial established 25 years previous as a basis for understanding the potential effects of climate change on species and populations. Growth and survival data from 21 sites were used with climatic variables to predict optimum temperature and precipitation conditions for white spruce survival and growth. Based on predictions of global circulation climate models for Ontario, optimal habitats for white spruce are expected to shift north by about 2° latitude. Survival will be best at current locations but productivity is expected to be reduced.)

Cole, W.G., (D.L. Farintosh), (J.L. Todd) and E.C. Mallory. 2003. **Ontario hardwood silviculture studies database: Annotated bibliography**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 153. 86 p.

(This report contains bibliographic citations and abstracts for 314 publications, reports, and other transfer products that are included in the publications section of the Ontario hardwood silviculture studies database. Studies were included in the bibliography if they occurred in Ontario, included some type of silvicultural treatments and measurements of resulting regeneration success or growth responses, and focussed on one or more of the following hardwood tree species: sugar maple, yellow birch, red oak, American beech, white ash, black cherry, or basswood.)

Cole, W.G., (K.E. Smokorowski), (T.C. Pratt) and E.C. Mallory. 2003. **Riparian forest and nearshore fish habitat in Ontario: So close and yet so far**. Pp. 13-15 *in* Meeting Emerging Ecological, Economic, and Social Challenges in the Great Lakes Region: Popular Summaries. Buse, L. J. and A.H. Perera, comp. Sault Ste. Marie, ON. 9-11 June 2003. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON.

For. Res. Inf. Pap. No. 155. 206 p.
(This popular summary describes the work being done to increase our understanding of the ecology of riparian zones and the influence of shoreline management on fish habitat.)

Colombo, S.J., (C. Glerum) and (D. P. Webb). 2003. **Daylength, temperature and fertilization effects on desiccation resistance, cold hardiness and root growth potential of *Picea mariana* seedlings**. Ann. For. Sci. 60: 307-317.
(*Picea mariana* (Mill.) B.S.P. seedlings were hardened for overwintering under 4 regimes. In 4 regimes, seedlings were kept inside a heated greenhouse for 11 weeks during and after dormancy induction (August to mid-November), with either (1) Natural daylengths (46° 31' N) and warm temperatures of 20 °C or more (NDW), (2) As (1), but fertilized (NDWF), or (3) As (1), but with shortened daylengths (SD). In the fourth regime (OD), seedlings were hardened outside at naturally declining temperatures and daylengths without fertilizer. Seedlings hardened in any warm temperature treatment had buds with more needle primordia and shoots more resistant to desiccation than OD seedlings. Initially, cold hardiness tended to be greatest in SD seedlings. As hardening progressed OD seedlings became equally cold hardy to SD. In late November when all trees were outside, NDW seedlings were usually least cold hardy. Spring root growth potential was least in OD seedlings.)

DeYoe, D. (comp.). 2003. **Principles to practice: Managing the development and delivery of science in a more business-driven environment** - Presentations from the Section 6.06 side event at the XII World Forestry Congress. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. Unpubl. CD-ROM.
(This CD-ROM contains copies of the powerpoint presentations from the *Principles to Practice: Managing the Development and Delivery of Science in a More Business-Driven Environment* side event at the 2003 World Forestry Congress. Topics range from managing to development and delivery of science in a more business-driven environment to ensuring that forest management and society get more out of forest research to increasing wood supply through science and education. Presenters hail from across North America and Europe, providing a diversity of perspectives on developing and delivering new information.)

DeYoe, D.R. and T.L. Noland. 2003. **Addressing resource sustainability and market uncertainty through business diversification: A case for bio-products and non-timber forest products**. Pp. 27-29 *in* Meeting Emerging Ecological, Economic, and Social Challenges in the Great Lakes Region: Popular Summaries. Buse, L. J. and A.H. Perera, comp. Sault Ste. Marie, ON, 9-11 June 2003. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 155. 206 p.
(Achieving resource sustainability, which is the mandate of governments and good business for the forest industry, can be accommodated by diversifying forest resource utilization through creative use of the forest resource. Two emerging innovations in the forest sector, non-timber forest products (NTFP) and bio-products, provide subsistence to full income opportunities for community entrepreneurs, and can diversify industrial options that help mitigate market uncertainties for companies. This summary describes a project that will focus on the use of forest resources as a source of products and services for key economic sectors, e.g., health, energy, environment, materials manufacturing, food, etc., and seeks to use the enabling technologies being developed as part of the bio-economy to address issues and opportunities associated with key focus areas: global climate change, forest health and productivity, and rural economic development.)

Greifenhagen, S. 2003. **Disease considerations in unmanaged boreal mixedwood forests of Ontario.** Ont. Min. Nat. Resour., For. Manage. Br., Sault Ste. Marie, ON. Boreal Mixedwood Note No. No. 32. 8 p.
(This note provides an overview of major diseases of boreal mixedwood forests including root diseases, stem decay, hypoxylon canker, stem rusts, and foliar diseases, as well as a summary of which crop tree species they commonly affect.)

Greifenhagen, S. and T.L. Noland (comp.). 2003. **A synopsis of known and potential diseases and parasites associated with climate change.** Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 154. 182 p.
(Current climate change models for Ontario predict that mean annual temperature will increase by up to 3°C over the next century. Temperatures are expected to increase more in winter than in summer, with an increase in frost-free days, and to increase more in northern than southern latitudes. Minimum temperatures should increase more than maximum temperatures. Precipitation, although somewhat unpredictable, is expected to increase in Ontario, but increased evaporation and transpiration due to warmer temperatures will likely result in drier conditions, particularly during the summer growing seasons. If Ontario's climate changes as predicted, many human, animal, and plant diseases that are affected by climate will also change in range, intensity, and/or a variety of other ways, in turn affecting the

health and well-being of people, animals, and plants in Ontario. This report identifies which diseases are likely to be affected by climate and which human, animal, and plant groups are most vulnerable to them. It also provides recommendations for changing disease management strategies and practices to mitigate the effects of climate change. Because we cannot predict precisely how climate change will affect disease and because the predicted changes may occur at a relatively fast pace, we must improve our knowledge base and our response capability at local, regional, and national levels to maintain current levels of health. Doing so will enable us to face the coming challenges, adapt to them, learn from them, and protect Ontario's communities and ecosystems. Includes popular summary and separate reports titled *A synopsis of known and potential diseases and parasites of humans and animals associated with climate change* and *Climate change and plant disease in Ontario*.)

(Hopkin, A.) and T.L. Noland. 2003. **Ice storm 1998 -- Results of research on impact, recovery and economics**. For. Chron. 79(1): 30.
(This note introduces the papers appearing in this special issue of the Forestry Chronicle that summarize research accomplishments in the 5 years since the 1998 ice storm.)

(Irvine, M.), P. Lu, (D.G. Pitt) and (R. Wilson). 2003. Screening fungicides for white pine blister rust control. Pp. 39-41 *in* White Pine Blister Rust Workshop. Wilson, R., comp. Ottawa, ON, Mar 27-28, 2003. Ont. Min. Nat. Resour./East. Ont. Model For. Unpubl. Rep. 74 p.
(This popular summary reports on a proposed project that will screen fungicides for blister rust control. While no fungicides are presently registered for white pine blister rust control, some that are registered for other species may work and programs exist that allow expanding registered labels for minor crops such as white pine.)

Lautenschlager, R.A., (J.H. Pedlar) and (C.M. Nielsen). 2003. **Ice storm damage: Effects of competition and fertilization on near-ground vegetation**. For. Chron. 79(1): 54-62.
(Increasing ice damage to tree canopies led to increased cover of near-ground deciduous tree species, herbaceous species, and total vegetative cover but reduced fern cover in managed sugar maple stands in southeastern Ontario. Near-ground vegetation did not respond to the addition of fertilizers [2000 kg/ha of dolomitic lime, 200 kg/ha of both phosphorus (P) and potassium (K), or lime plus P and K]. Vegetation management with glyphosate in these stands reduced near-ground deciduous tree cover by 86%, while grass and sedge cover were reduced 69%, and shrub cover was reduced 98% 2 years after treatment. Although species richness was initially reduced by vegetation management, species richness levels on treated plots were comparable to, or higher than, those on untreated plots by 2 years following treatment.)

Lautenschlager, R.A., (J.H. Pedlar), J.A. Winters and (C.M. Nielsen). 2003. **Ice storm damage: Effects of competition and fertilization on the growth of sugar maple trees**. For. Chron. 79(1): 63-69.
(Treatment plots in blocks established in productive sugar maple bushes throughout southeastern Ontario were used to quantify effects of fertilizers, vegetation control, and interactions on maple growth following the 1998 ice storm. Treatments were applied during the spring of 1999. Increment cores from 6 mature sugar maple trees in each plot in each block were extracted and examined during October 2001. Maple growth was highly variable before the storm, but fell to a 30-year low during both the first and second year after the storm. Growth reductions increased with increasing crown damage. Treatment-related statistical differences were marginal; however, the data suggest that phosphorus and potassium additions and competition control improved the growth of ice-damaged mature sugar maple trees. The combination of competition control and fertilization increased growth of ice-damaged maple the most.)

Lu, P. and B. Sinclair. 2003. **A research plan for blister rust resistance in eastern white pine (*Pinus strobus* L.).** Pp. 57-60 *in* White Pine Blister Rust Workshop. Wilson, R., comp. Ottawa, ON, 27-28 Mar 2003. Ont. Min. Nat. Resour./East. Ont. Model For. Unpubl. Rep. 74 p.
(This popular summary outlines a strategy for developing blister rust resistance in eastern white pine that involves (1) searching for resistant families and (2) interspecific hybridizing of eastern white pine with resistant 5-needle pines from Asia.)

Lu, P., (D.G. Joyce) and R.W. Sinclair. 2003. **Effect of selection on shoot elongation rhythm of eastern white pine (*Pinus strobus* L.) and its implications to seed transfer in Ontario.** For. Ecol. Manage. 182(2): 161-173.
(Shoot elongation patterns of eastern white pine from 112 natural populations in Ontario were studied for 2-year-old seedlings in a greenhouse and 7-year-old trees in a field provenance test. Shoot elongation curves were fitted with a logistic function for individual seedlings and trees, from which several shoot elongation rhythm variables were predicted. The effects of within population selection for increased growth on the shoot elongation rhythm variables

were investigated at different selection intensities. Results indicate that faster growth in eastern white pine is associated with both an earlier start and later cessation of shoot elongation for individuals and populations. While among population variation is significant, from 83 to 92% of phenotypic variation in estimates of shoot elongation curve parameters and growth rhythm variables resides within populations, which tends to minimize the effects of geographic seed transfer on the synchronization between shoot growth rhythm and local climate. Within a population, selections for increased growth can result in substantial change in population statistics of shoot growth rhythm variables. A selection intensity as low as 50% in height growth can delay shoot elongation cessation by nearly 6 days and expand the shoot elongation period by 8 days. The implications of changes in shoot elongation rhythms to seed transfer in Ontario are discussed.)

Lu, P., (D.G. Joyce) and R.W. Sinclair. 2003. **Geographic variation in cold hardiness among eastern white pine (*Pinus strobus* L.) provenances in Ontario**. For. Ecol. Manage. 178(3): 329-240.
(Needle and shoot samples of eastern white pine provenances in Ontario were subjected to a series of artificial freezing tests to determine provenance differentiation in fall and winter cold hardiness. Results indicated that under the natural processes of cold acclimation in the fall, aboveground tissues of eastern white pine could withstand low freezing temperatures in September–October that exceeded the local long-term minimum climate extremes of the same period. The severity of cold damage increased at a faster rate in September than in October and November when temperature was further decreased below the thresholds that started to cause cold damage. Under the selected freezing temperatures that inflicted between 15 and 85% average needle or/and cambium damage, consistent results were observed among freezing tests that were conducted using samples of different ages and cold acclimation stages. A clinal pattern of geographic variation in the severity of cold damage was detected with a trend parallel to that of growth potential. As thermal conditions improve from the north to south in Ontario, the growth potential of a provenance increases but the degree of cold hardiness decreases. Based on risk assessments using a spatial regression approach, it was, however, believed that northward seed transfer within a distance of 2–2.5° in latitude could be acceptable to promote stand growth while incurring no statistically significant increase in cold damage.)

Lu, P., (D.G. Joyce) and R.W. Sinclair. 2003. **Seed source selection of eastern white pine**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Note No. 64. 4 p.
(This publication presents results of a genecology study that investigated how well white pine grown from seed from this species' range in eastern Ontario would grow if planted at 2 test sites, a more severe site near Sault Ste. Marie and a milder site near Simcoe (Turkey Point). Researchers also subjected shoot and needle tissues from seedlings grown from these same seed sources to extreme conditions simulated in a growth chamber to test how well they tolerated frost damage. Among their findings: Overall, seed from more southerly and warmer areas grew faster; thus, moving a seed source 1o north in latitude could increase height growth significantly in the first 5 years (in turn increasing forest productivity and carbon sequestration). However, moving seeds north increases the risk of frost damage, as the seedlings may break bud and start growing before the frost-free date. Among the recommendations: To prevent reductions in growth, avoid using seed collected north of the planting area; to get increased growth with minimal risk of frost damage, use seed from 1.5 to 2o south of the planting area. These results may be particularly relevant to forest managers who are investigating moving seed sources north to help offset future increases in temperature due to global warming.)

MacDonald, G.B. and D.J. Thompson. 2003. **Responses of planted conifers and natural hardwood regeneration to harvesting, scalping, and weeding on a boreal mixedwood site**. For. Ecol. Manage. 182(2): 213-230.
(Recent emphasis on ecosystem-based forest management has increased interest in promoting species mixtures to enhance stand-level diversity. However, little information is available on silvicultural approaches to regenerate mixtures of conifers and hardwoods in northern Ontario. This study tested fifth-year effects of harvest intensity (uncut, 50% partial cut with and without removal of residuals after 3 years, and clearcut), site preparation level (none and scalped), and chemical weeding frequency (none, single, and multiple) on survival and growth of planted white spruce and jack pine, height and density of hardwood regeneration, and cover of competing shrubs. The study is located in a hardwood-dominated mixedwood stand on a fertile, mesic, upland site in northeastern Ontario. Although throughfall precipitation, wind speed, and temperature were moderated by residual cover, only light level varied sufficiently among treatments to account for differences in regeneration success.

Damage to regeneration by mammals, weather, or equipment was minor, but up to 17% of residual basal area was lost to windthrow in partial cuts. Scalping had no effect on the development of conifer seedlings, hardwood regeneration, or shrubs. Survival of conifer seedlings was enhanced by harvesting but not by weeding, and spruce survival exceeded pine survival at all harvest levels. Seedling height and diameter growth increased with harvest intensity and weeding frequency, and the beneficial effects of weeding increased with harvest intensity. Height and density of hardwood regeneration increased with harvest intensity and decreased with weeding frequency. Single weeding reduced but did not eliminate hardwoods. Harvesting slightly increased shrub cover and weeding sharply decreased it. Dense suckering of trembling aspen followed removal of residuals 3 years after the initial 50% partial cut. Thus, final removal cuts on mixedwood sites should be delayed until conifer seedlings are well established. Underplanting cannot be recommended for uncut mixedwood stands in Ontario because of unacceptably high seedling mortality. Compared to clearcutting, partial cutting without removal of residuals reduced fifth-year hardwood density on unweeded plots. However, hardwoods on that treatment overtopped spruce seedlings by 90 cm and pine seedlings by 64 cm. Partial cutting with reduced weeding produced acceptable stocking of conifer and hardwood regeneration, but did not promote seedling growth. Weeding was required to maintain spruce as a viable understory component, to ensure pine codominance with hardwoods, and to reduce shrub cover below 50%. Separating species into alternating patches or corridors may be more productive than promoting integrated mixtures, since it allows silvicultural treatments to be adapted to the needs of each species. Long-term monitoring of crop trees and associated vegetation following mixedwood management options on a range of boreal sites is required to advance the knowledge base and produce reliable operational guidelines.)

MacDonald, G.B., J.A. Rice, J. McLaughlin, (J. Pearce), (L. Venier), (K. Nystrom) and (P. Meek). 2003. **Developing sustainable mixedwood practices in a stand-level adaptive management (SLAM) framework: Project establishment**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 157. 17 p.
(Forest managers in Ontario need reliable guidelines for promoting desirable species mixtures to enhance economic and ecological diversity. The objective of this project is to advance knowledge of boreal mixedwood (BMW) management by testing techniques for achieving productive mixtures of conifers and hardwoods at operational scales. Treatments are being applied in aspen-dominated BMW stands on the limits of Abitibi-Consolidated Inc. and Domtar Inc. in northeastern Ontario. Contrasting approaches are being compared (blended mixtures vs. mosaics, partial cutting vs. herbicide application, shade-tolerant vs. shade-intolerant conifer regeneration) to help identify best practices. Treatment effectiveness will be assessed by measuring regeneration growth, vegetation succession, soil nutrient dynamics, and changes in invertebrate populations. Operational feasibility will be evaluated by estimating costs for all elements of the treatments. The project plan is based on the active adaptive management (AAM) steps of *assess, design, implement, monitor, evaluate,* and *adjust*. Government, industry, non-profit, and academic partners have made long-term commitments and accepted clearly defined roles related to the AAM framework for this project. Knowledge gained will be transferred using techniques matched to the needs of specific client groups (policymakers, forest managers, the science community, and the public) and recommendations on applying AAM in forestry will be developed. Since this project will be implemented in an adaptive management framework that emphasizes practical applications, incorporating the results into provincial silvicultural guides and forest management plans will be a high priority. This report provides an overview of study sites and methodologies.)

MacDonald, G.B. and (J. Elliott). 2003. **Applying crown and bole allometry to management of boreal mixedwood species**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Rep. No. 162. 13 p.
(The effectiveness of crown characteristics for estimating growth potential of boreal mixedwood species was tested, and allometry of crowns and boles was used to develop management recommendations. One thousand trees were destructively sampled in 4 mature boreal mixedwood stands in northwestern Ontario. Crown characteristics performed similarly to commonly reported competition indices in explaining tree growth variation, while avoiding drawbacks associated with developing and applying competition indices in boreal mixedwood stands. Live crown ratio (LCR) weighted by estimated crown fullness explained 36%, 53%, and 57% of diameter growth variation in black spruce, white spruce, and balsam fir, respectively. Since crowns integrate competitive effects over several growing seasons, average crown characteristics may estimate productivity potential better than a competition index measured at a single point in time. Differences in mean crown characteristics, diameter growth

efficiency, and slenderness coefficient among crown positions were often unique to each species, indicating a potential role for these measures in guiding management decisions. Species-specific recommendations appropriate for the sampled stands were proposed. More research is needed to develop tree allometry as a tool for large-scale management of diverse forest types.)

McLaughlin, J.A. 2003. **Developing a site-based hazard rating system for white pine blister rust in Ontario**. Pp. 71-74 *in* White Pine Blister Rust Workshop. Wilson, R., comp. Ottawa, ON, 27-28 Mar 2003. Ont. Min. Nat. Resour./East. Ont. Model For. Unpubl. Rep. 74 p.
(This popular summary outlines a project proposed to develop an interactive decision support tool to assist white pine managers to identify risk of white pine blister rust infection on given sites.)

McLaughlin, J.A. 2003. **Managing disease in boreal mixedwood stands**. Ont. Min. Nat. Resour., For. Manage. Br., Sault Ste. Marie, ON. Boreal Mixedwood Note No. No. 33. 8 p.
(This note provides an overview of how mixedwood silvicultural practices may affect disease occurrent and effects and outlines management considerations for minimizing losses to diseases such as root disease, cankers, and stem decay.)

(Moorthy, I.), (J.R.Miller), (P.J. Zarco-Tejada) and T.L. Noland. 2003. **Needle chlorophyll content estimation: A comparative study of PROSPECT and LIBERTY.** *In* Proc. International Geoscience and Remote Sensing Symposium 2003. Learning From Earth's Shapes and Colors. Toulouse, France, 21-25 July 2003. IEEE, 3 p.
(Inversion capabilities of leaf-level radiative transfer models, PROSPECT and LIBERTY, were evaluated to estimate needle chlorophyll content from measured needle reflectance and transmittance spectra. Sensitivity studies, using simulation results, were conducted on the models' biophysical parameters to determine robust inversion approaches. Unlike PROSPECT, which has only one scattering parameter (N), the LIBERTY model comprises 2 highly sensitive scattering parameters (average cell diameter and intercellular air gap), which influence visible and near infrared spectral characteristics and challenge usual iterative minimization techniques. Validation of inversion algorithms were based on jack pine needles, collected in forested areas near Sudbury, Ontario, Canada, between June and September 2001 for laboratory spectral and biochemical measurements. Both PROSPECT and LIBERTY would be used to accurately invert model-simulated reflectance and transmittance spectra for needle pigment content. However, inversions using actual data have proven more challenging. For PROSPECT, with an empirically determined geometric form factor to account for needle shape, inversions using measured spectra yield pigment estimates with an RMSE of 13 ug/cm$^2$ over a pigment range between 15 and 68 ug/cm$^2$. For LIBERTY, current efforts focus on effectively accounting for the highly sensitive model scattering parameters to permit accurate inversion of measured needle spectra for pigment estimation. Comparisons of inversion results using both PROSPECT and LIBERTY as well as contrasts in the sensitivity of specific model parameters to retrieval accuracy are presented. Such assessments of leaf-model inversion capabilities are necessary prior to coupling it with canopy models to make stand-level pigment estimations.)

(Moorthy, I.), (J.R. Miller), T.L. Noland, (U. Nielsen) and (P.J. Zarco-Tejada). 2003. **Chlorophyll content estimation of boreal conifers using hyperspectral remote sensing**. *In* Proc. International Geoscience and Remote Sensing Symposium 2003, Learning From Earth's Shapes and Colors. Toulouse, France, 21-25 July 2003. IEEE, 3 p.
(This investigation quantitatively links physiologically based estimators of forest stand condition, such as chlorophyll concentration, to hyperspectral observations of jack pine, a dominant boreal forest species. Between June and September 2001, 4 intensive field campaigns of data collection were conducted over the forested areas near Sudbury, Ontario, Canada. Using the CASI sensor, data were collected, in the visible and near infrared domain, over 8 selected jack pine sites. Supplementing the airborne campaigns was simultaneous on-site collection of foliage samples for laboratory spectral and chemical measurements. The study first linked needle-level reflectance and pigment content through the inversions of leaf level radiative transfer models such as PROSPECT. Next, the red-edge index (R750/710) was scaled up to the canopy level through the use of canopy models and infinite reflectance calculations, which simulate the canopy as an optically thick vegetation medium. However, for the relatively open and clumped jack pine stands such a simple approach requires careful validation due to the confounding effects of the open canopy structure. Accordingly, the analysis has focused on high spatial resolution CASI imagery (1 m) for which tree crowns, shadows, and open (sun-lit) understory can be identified visually and approaches can be examined for validity and effects. Effectively eliminating these confounding variables will permit the generation of predictive needle pigment content maps for forest condition assessment.)

Noland, T.L. 2003. **1998 ice storm impact on sugar bushes of eastern Ontario**. For. Chron. 79(1): 75-81.
(In 1998, 34 managed sugar bush blocks with 7% to 72% ice-induced crown damage were established in eastern Ontario. All received dolomitic lime (Ca, Mg) and P and K treatments in June 1999. Initial crown damage, fall root starch and sugar levels, sap production and sweetness, sap amino acid concentration, and tap hole closure rate were measured. Syrup production was calculated. Trees with >50% (severe) crown damage had reduced root starch content in 1998 and 2000, but not in 1999. In 2000, root total sugars were lower in trees with >50% crown damage. Sap produced per tap, and sap sweetness were reduced by damage, but not consistently in all years. Sap per tap increased with total crown branches in all 3 years, but sap sweetness and syrup production increased only in 1999. Syrup production per tap was consistently reduced in damaged trees in all 3 years, usually in trees with >50% damage. The lime and P and K treatments did not significantly affect any of the variables measured. Results suggest that severe ice storm damage to crowns resulted in reduced fall root starch levels and less sap production, and/or sap sweetness, and therefore lowered the syrup producing capacity of sugar maple.)

Noland, T.L., (J.R. Miller), (I. Moorthy), (C. Panigada), (P.J. Zarco-Tejada), (G.H. Mohammed) and (P.H. Sampson). 2003. **Bioindicators of forest sustainability: Using remote sensing to monitor forest condition.** Pp. 75-77 *in* Meeting Emerging Ecological, Economic, and Social Challenges in the Great Lakes Region: Popular Summaries. Buse, L. J. and A.H. Perera, comp. Sault Ste. Marie, ON, 9-11 June 2003. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 155. 206 p.
(This popular summary provides an update on the bioindicators of forest condition project, which has determined for example that remote sensing-derived estimates of maple stand chlorophyll concentration can be used to estimate forest stand condition. While developing similar methods for estimating chlorophyll in boreal species will be challenging for jack pine and black spruce, it looks promising for poplar and white birch.)

Obenchain, A.M. (ed.). 2003. **Insights**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. 6(1): 12 p.
(This issue of OFRI's newsletter includes an overview of the uses for models in forest management, a summary of OFRI's technology transfer survey results, information about the aspen decline problem in northeastern Ontario, and summaries of new publications including a 5-year bibliography of OFRI's research publications.)

(Olthof, I.), (D.J. King) and R.A. Lautenschlager. 2003. **Overstory and understory leaf area index as indicators of forest response to ice storm damage**. Ecol. Indic. 3(1): 49-64.
(Leaf area index (LAI) was measured with the tracing radiation and architecture of canopies (TRAC) optical instrument in consecutive summers from 1999 to 2001 in sugar maple forests across eastern Ontario to monitor recovery from ice storm damage suffered in January 1998. The study sites were MNR experimental blocks designed for monitoring the effects of fertilizer and lime treatments on maple recovery. Understory vegetation survey data, collected in 1999 and again in 2001, were converted to understory gap fraction, and processed in the same manner as the TRAC data to obtain understory LAI. Subtraction of understory LAI from total LAI measured with the TRAC allowed monitoring of productive, overstory trees tapped for syrup production. Annual LAI measurements and LAI change were evaluated in relation to percent crown loss estimates and plot treatments. Understory, overstory, and total LAI increased from year to year in most plots. Of the single year measurements, total LAI measured in 1999 was significantly related to damage, while 2000 and 2001 LAI accounted for progressively less of the variation in damage, indicating a change in canopy condition between seasons. Understory LAI increased dramatically in response to overstory crown loss, while overstory increased more in absolute terms, but less in relative terms. Between-season LAI change was more significantly related to damage than any of the annual LAI measurements to which it was compared, indicating that LAI response is a better indicator of damage than single year LAI. LAI change was not, however, significantly related to plot treatment.)

Parker, W.C. 2003. **The effect of ice damage and post-damage fertilization and competition control on understory microclimate of sugar maple (*Acer saccharum* Marsh.) stands**. For. Chron. 79(1): 82-90.
(The influence of ice damage, fertilization, and herbicide treatments on understory microclimate was examined in several sugar maple stands during 3 growing seasons. Stands with greater initial crown damage and lower leaf area index had higher understory light levels, elevated air temperatures, and lower humidity. Ice damage had comparatively less effect on the below-ground environment. Stands

with higher damage and lower leaf area index exhibited higher soil temperature and lower soil moisture availability in certain years. The strength and significance of the relationships of canopy features with microclimatic variables diminished over time with canopy recovery and growth of understory vegetation. Fertilization treatment effects on stand microclimate were not apparent, but competition control reduced understory leaf area, increased soil temperature, and had minimal influence on soil moisture status.)

Parker, W.C. and S.J. Colombo. 2003. **Breaking the constant climate paradigm: Intransigence in forestry in the face of impending climate change**. Pp. 79-81 *in* Meeting Emerging Ecological, Economic, and Social Challenges in the Great Lakes Region: Popular Summaries. Buse, L. J. and A.H. Perera, comp. Sault Ste. Marie, ON, 9-11 June 2003. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 155. 206 p.
(This popular summary provides an overview of some of the ways that climate change and elevated carbon dioxide could affect northern forest ecosystems, implications for forest management, and what forest managers can do to minimize negative effects.)

Parker, W.C. and S.J. Colombo. 2003. **Modelling the future forest: Establishing a sound basis for climate change research**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Note No. 66. 4 p.
(Growing plants in a range of environments is a highly useful way of understanding how trees may adapt to climate change. Climatologists are predicting rapid and extreme changes on a global scale, and climatic conditions anticipated for the latter part of this century can be mimicked using controlled environment facilities. One of the most sophisticated collections of controlled environment facilities in Canada exists at the MNR's Ontario Forest Research Institute (OFRI) in Sault Ste. Marie, Ontario. This note describes how these facilities can contribute to ongoing climate change research efforts using examples of past OFRI research. The equipment available for measurement of plant physiological variables will allow researchers to predict how future climate may affect plant growth and physiological processes. Associated laboratory facilities provide the capacity to determine the influence of climatic perturbations on plant nutrient relations, plant biochemistry, and plant anatomy. These facilities can be used to address questions about the effect of climate change on forest ecosystems and their management.)

(Parton, J.), (M.Roddick) and (M. Woods). 2003. **The carbon budget of Ontario's forests: Phase I: The carbon stocks of Ontario's managed forest lands for 1990 -- The monitoring network**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Note No. 63. 4 p.
(Carbon management is at the centre of efforts to mitigate the impacts of rapid climate change through emissions reduction and carbon storage under the Kyoto Protocol. Given that forested ecosystems can store significant amounts of carbon and could be used as a carbon sink under Kyoto, carbon management projects must be rigorously monitored and their results verified and reported. This note provides an overview of the monitoring network of permanent sample plots that was established using MNR's current methods as a basis for developing a geographically extensive and comprehensive database for Ontario's forests. These data permitted calibration of the Carbon Budget Model for the Canadian Forest Sector to estimate Ontario's carbon budget for 1990.)

Peng, C., (Q. Dang), (J. Liu), (X. Zhou) and (J. Chen). 2003. **Quantifying Ontario's forest carbon budgets: I. Developing and testing a dynamic forest carbon budget model for Ontario**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Note No. 65. 4 p.
(This publication reports on researchers' progress in developing a new and dynamic forest growth and carbon budget model for Ontario. Resource managers will be able to use this model, known as TRIPLEX, to investigate the effects of disturbances such as fire, harvesting, and insect and disease outbreaks on carbon stocks as well as to predict Ontario's forest carbon budgets to the year 2010. The results presented here indicate that TRIPLEX provides reasonable estimates of height, diameter at breast height, and stem density for jack pine stands in northern Ontario. Next steps including testing the model's ability to simulate net primary productivity, belowground biomass, and soil carbon, nitrogen, and water dynamics for various forest ecosystems in Ontario and developing new modules for TRIPLEX that simulate the effects of carbon dioxide fertilization and disturbance on forest growth and carbon dynamics.)

Perera, A.H., (D. Baldwin), (F. Schnekenburger), (D. Yemshanov), (D. Boychuk) and (K. Weaver). 2003. **Characterizing boreal forest landscape disturbance dynamics: Components of bounds of natural variation**. Pp. 193-195 *in* Meeting Emerging Ecological, Economic, and Social Challenges in the Great Lakes Region: Popular Summaries. Buse, L. J. and A.H. Perera, comp. Sault Ste. Marie, ON, 9-11 June 2003. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 155. 206 p.

(Characterizing boreal forest landscape dynamics at large scales (large extents over long periods) is rapidly becoming a popular topic among researchers and forest practitioners alike, using methods that range from extrapolating historical evidence to scenario simulation modelling. Because of the non-deterministic properties of disturbance regimes and post-disturbance responses of landscapes, it is equally important to understand the inherent variability associated with landscape dynamics. Generally, this viability is referred to as 'bounds of natural variation' in disturbance dynamics. Studies that attempt to understand disturbance dynamics via natural history techniques term it "historical range of variability." This popular summary discusses aspects of variation associated with forest landscape dynamics: *spatial* variability, *temporal* variability, and *stochastic* variability, and their incorporation into spatial disturbance dynamics models.)

Perera, A.H., D.J.B. Baldwin, D.G. Yemshanov, F. Schnekenburger, K. Weaver and (D. Boychuk). 2003. **Predicting the potential for old-growth forests by spatial simulation of landscape ageing patterns**. For. Chron. 79(3): 621-631.
(Planning for old-growth forests requires answers to two large-scale questions: How much old-growth forest should exist? And where can they be sustained in a landscape? Stand-level knowledge of old-growth physiognomy and dynamics are not sufficient to answer these questions. We assert that large-scale disturbance regimes may provide a strong foundation to understand the spatio-temporal ageing patterns in forest landscapes that determine the potential for old growth. Approaches to describe large-scale disturbance regimes range from scenarios reconstructed from historical evidence to simulation of landscapes using predictive models. In this paper, we describe a simulation modelling approach to determine landscape-ageing patterns, and thereby the landscape potential of old-growth forests. A spatially explicit stochastic simulation model of landscape fire and forest cover dynamics was applied to a 1.8 million-ha case study boreal forest landscape to quantify the spatio-temporal variation of landscape ageing. Twenty-five replicates of 200-year simulation runs of the fire disturbance regime, at a 1-ha resolution, generated a suite of variables of landscape ageing and their error estimates. These included temporal variation of older age cohorts over 200 years, survivorship distribution at the 200$^{th}$ year, and spatial tendencies of ageing. This information, in combination with spatial tendency of species occurrence, constitutes the contextual framework to plan how much old-growth forest a given landscape can sustain, and where such forest could be located.)

Perera, A.H., (F. Schnekenburger), (D. Baldwin), (D. Boychuk), (D. Yemshanov) and (K. Weaver). 2003. **BFOLDS - A spatially explicit stochastic model to simulate boreal forest landscape dynamics**. Pp. 189-191 *in* Meeting Emerging Ecological, Economic, and Social Challenges in the Great Lakes Region: Popular Summaries. Buse, L. J. and A.H. Perera, comp. Sault Ste. Marie, ON, 9-11 June 2003. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 155. 206 p.
(There is an ever-increasing need to study the large-scale fire regimes and subsequent forest cover changes in the boreal forest biome. This knowledge is critical to understand the possible effects of climate change, comprehend the role of forests in carbon sequestration, and develop sustainable forest management plans for boreal forests. This popular summary describes the scenario simulation model (Boreal FOrest Landscape Dynamics Simulator - BFOLDS), which was developed to characterize and predict large-scale forest fire regime and forest cover dynamics in Ontario's boreal biome. This model's development was especially motivated by the growing need to characterize and understand potential fire-landscape dynamics for policy formulation in Ontario.)

Perera, A.H. and L.J. Buse. 2003. **To emulate natural forest disturbance or not?** Pp. 185-187 *in* Meeting Emerging Ecological, Economic, and Social Challenges in the Great Lakes Region: Popular Summaries. Buse, L. J. and A.H. Perera, comp. Sault Ste. Marie, ON, 9-11 June 2003. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 155. 206 p.
(The emergence of emulating natural forest disturbance (ENFD) as a forest management paradigm has caused resource managers to ask many questions about its appropriateness and associated mechanisms. This popular summary provides an overview of the rationale for ENFD, presents a working definition for ENFD, and highlights some aspects of its practice and future.)

(Pitt, D.), (T. Meyer), D. Thompson, M. Park and (L. MacDonald). 2003. **Use of the fungicide Bayleton (Triadimefon) in the prevention of white pine blister rust**. Pp. 35-38 *in* White Pine Blister Rust Workshop. Wilson, R., comp. Ottawa, ON, 27-28 Mar 2003. Ont. Min. Nat. Resour./East. Ont. Model For. 74 p.
(This popular summary reports initial results of attempts to increase white pine blister rust resistance using triadimefon fungicide -- a slow-release tablet applied at time of planting. Preliminary results indicate that white pine regeneration success requires an integrated pest management approach that includes

low hazard site selection, use of healthy planting stock, weed control, and pruning.)

(Pitt, D.), W.C. Parker, (A. Morneault), (A. Stinson), F.W. Bell and (L. Lanteigne). 2003. **McConnell Lakes white pine competition studies: Status report 2003 field season**. Forestry Research Partnership, Mattawa, ON. Unpubl. Rep. 36 p.
(This report summarizes the establishment and preliminary results of 3 white pine vegetation management studies, 2 in Ontario and 1 in New Brunswick. These projects are intended to help determine when and how best to manage vegetation in white pine stands to maximize production and quality.)

(Sampson P.H.), (P.J. Zarco-Tejada), (G.H. Mohammed), (J.R. Miller) and T.L. Noland. 2003. **Hyperspectral remote sensing of forest condition: Estimating chlorophyll content in tolerant hardwoods.** For. Sci. 49(3): 381-391.
(To develop practical and objective measures of forest condition, the Bioindicators of Forest Sustainability Project has used a physiological, remote sensing approach that emphasizes identifying early warning measures of stress effects in forests. While stress indicators exist at the leaf level (e.g., chlorophyll fluorescence, pigment levels), developing reliable indicators at the canopy level is a challenge. Hyperspectral sensors, such as the Compact Airborne Spectrographic Imager (CASI), may be useful in remotely detecting vegetation stress effects. In this study, an inverse modeling approach demonstrated that the CASI could be used to map chlorophyll content (root mean square errors ranging from 12.6 to 13.0 mg/cm$^2$) following different silvicultural treatments in a tolerant hardwood (sugar maple) forest. This capability could be readily applied to operationally assessing forest physiological strain and in classifying forest condition based on chlorophyll content. A change analysis study was also conducted to evaluate chlorophyll estimation across seasons for a range of sites. The implications of these findings and recommendations for a prototype system to monitor forest condition are presented.)

Schnekenburger, F. and A.H. Perera. 2003. **Regional-scale forest net primary productivity assessment software (NPPAS): A user's guide.** Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 156. 26 p.
(Monitoring and assessing net primary productivity (NPP) has become an important aspect of forest landscape management. In Ontario, the formal forest management planning process requires reporting on regional-scale NPP. We developed a software package known as *Net Primary Productivity Assessment Software* or *NPPAS* to enable inexpensive and rapid assessment of NPP at 1 m spatial resolution and at 1-year intervals, using AVHRR-NDVI imagery (AVHRR stands for *advanced very high resolution radiometer*; NDVI is *normalized difference vegetation index*). While this software is customized for use in Ontario, its principles are applicable to other northern forest landscapes. This report provides an overview of NPPAS and directions for the first-time user.)

(Shoemaker, R.A.), J. McLaughlin, S. Greifenhagen and (S. Hambleton). 2003. **Fungi canadensis No. 345: *Asteromassaria olivaceohirta*.** Can. J. Plant Pathol. 25:384-386.
(This note describes the recognition, classification, hosts, distribution, germination, and impacts of the fungus *Asteromassaria olivaceohirta*, which was recently found colonizing red mulberry (*Morus rubra* L.) in Ontario. This is significant because red mulberry is classified as endangered and this fungus, although previously identified in Ontario, was not known to affect this particular shrub.)

Sinclair, B. 2003. **History and status of blister rust screening in Ontario**. Pp. 24-27 *in* White Pine Blister Rust Workshop. Wilson, R., comp. Ottawa, ON, 27-28 Mar 2003. Ont. Min. Nat. Resour./East. Ont. Model For., Unpubl. Rep. 74 p.
(This popular summary summarizes efforts to find and establish blister rust resistant eastern white pine in Ontario in the 1940s and 1950s and highlights current efforts to reexamine and continue to build on those efforts.)

(Suffling, R.), (M. Evans) and A.H. Perera. 2003. **Presettlement forest in southern Ontario: Ecosystems measured through a cultural prism**. For. Chron. 79(3): 485-501.
(To better manage southern Ontario's natural forests, the former and present status of old growth must be understood. We hypothesize that old-growth pine (*Pinus* spp.), although dominant elsewhere, was less common in southern Ontario than popular history suggests; we are obliged to evaluate historical information that has been filtered both by the original compilers and through our own biases. Until recently, Ontario research emphasized the old-growth pine stands of central and northern Ontario to the relative exclusion of other kinds of old forest because very few southern Ontario old-growth stands remained to study. Ontario forest resource inventory data (FRI) show stands of over 150 years totalling only 1475 ha in 1978, concentrated on the Oak Ridges Moraine, the St. Lawrence Valley and the Awenda Peninsula. Red and eastern white pine stands constituted only 5.3% of the 1978 forested area, with virtually none over 150 years, whereas eastern hemlock stands constituted 12.8%. The difficulty in finding modern old

growth necessitates historical reconstruction using physical, written and graphical resources, including early survey records and trade statistics. In a case study of 1822 survey data from Darling Township (Lanark Co.) and 1960 FRI, vegetation was classified using TWINSPAN and mapped using ARC/INFO Thiessen polygons. Dominant hemlock occupied half the township but it has since been eliminated as a dominant. Conversely, there were no pine-dominated forests in 1822, but these had increased to 16% of the area by 1960. A second case used similar methods, with 1855 data for St. Edmunds and Lindsay townships (Bruce Co.) and 1981 FRI. Although logging halved the area and reduced the stature of pines in the large pinery, the elimination of dominant hemlock (originally 41% by area) is more significant. Fragmentary square timber trade data suggest that at least half the large pines in Bruce County were in St. Edmunds, so pine must have been spectacularly concentrated in a few areas. The third case, a map constructed from Gourlay's 1817-1819 survey, also demonstrates that pine-dominated areas were in the minority in southern Ontario, concentrated on sandy soils around Lakes Ontario and Erie. However, big hemlocks, beeches, maples and oaks were much more common overall. Management responses to this information should include designation of older southern Ontario forest stands (especially those never cleared since settlement) for maturation into an old-growth state, and the systematic restoration of eastern hemlock and beech stands for conservation purposes in southern Ontario.)

(Thompson, I.D.), (J.A.Baker) and M.T. Ter-Mikaelian. 2003. **A review of the long-term effects of post-harvest silviculture on vertebrate wildlife, and predictive models, with an emphasis on boreal forests in Ontario, Canada**. For. Ecol. Manage. 177:441-469.

(Greater fibre yields may be possible in commercial forests through an increased application of post-harvest silvicultural techniques. In Canadian boreal forests, while basic silvicultural regeneration techniques such as planting, seeding, scarifying, and tending, have been used since the 1940s, more intensive techniques (intensive forest management (IFM)) such as increased area planted, pre-commercial and commercial thinning, extra tending events, fertilizing, and short rotations may soon be used. There may be effects of basic and more intensive silviculture on biodiversity in the long-term, compared to natural regeneration following harvesting or especially stand development following natural disturbances. We reviewed approximately 50 papers that reported studies of the long-term effects of post-harvest silviculture on vertebrate wildlife. In particular, large impacts to biodiversity universally occur when native forest types are replaced by rapidly growing exotic tree species. However, in boreal forests, native tree species are usually planted, and so any effects on associated wildlife communities may be considerably less than in non-native species plantations. Limited long-term information is available, but published studies of effects of basic silviculture and IFM suggested that loss of structures in forest stands was an important common impact that resulted in vertebrate species responses. Fewer structural features in managed forests compared to in natural forests likely results in reduced numbers of animal species dependent on those structures, such as cavity-using species and species for which large decaying woody debris is important. Simplifying stand structures and species composition may result in systems with low connectivity, making them vulnerable to insect and mammalian herbivory. Concentration of IFM in stands on highly productive sites could exacerbate effects (positive or negative), owing to the positive relationship between forest productivity and animal and plant diversity. Species such as black-backed woodpeckers may be reduced over large areas by stand conversion to mixedwoods, stand structural changes, and especially age-class truncation. On the other hand, IFM may contribute increased habitats to species favouring young to mature coniferous-dominated forests, that normally decline across a landscape following clearcutting in boreal mixed and upland conifer stands. An aspatial model, based on published and local information and expert opinion, suggested that IFM and post-harvest silviculture in Ontario's boreal forests would produce positive and negative species-specific effects on the vertebrates that we modelled. However, IFM appeared to result in little increased effect over basic post-harvest silviculture. We also expect that stand-level effects of IFM on species would accumulate through time over landscapes as more stands come under intensive management, and the level of effects will be cumulative.)

(Timmer, V.R.) and (Y. Teng). 2003. **Increasing carbon sequestration through enhanced stand establishment practices: Nursery nutrient loading.** Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Rep. No. 161. 15 p.

(Improving early performance of outplanted tree nursery stock under stressful and competitive conditions is crucial to the success of establishing new forests. Vigorous growth in juvenile plantations can last decades, and seedlings raised under steady-state nutrient-loading conditions in the nursery may outperform conventional seedlings in early growth after outplanting. We estimated the long-term potential of enhanced reforestation using nutrient-loaded seedlings to increase carbon sequestration using black spruce plantations in northern Ontario as a case study. The

study involved widely applied mathematical stand modelling procedures. Published early growth data of outplanted nutrient-loaded and conventional seedlings were pooled to calibrate and select the fittest model for predicting growth of maturing plantations. Tree height estimates were converted to biomass and carbon content to express post-planting response of nursery nutrient loading on future plantation productivity and carbon sequestration. Model results indicate that plantations generated from nutrient-loaded seedlings on a typical hardwood/mixedwood site in northern Ontario may sequester carbon at 143.1 Mg ha 1 in a normal rotation, which is 31.9% greater than that of plantations generated from conventional seedlings (108.6 Mg ha 1).)

Yemshanov, D. and A.H. Perera. 2003. **Synthesizing published knowledge of boreal forest cover change for large-scale landscape dynamics modelling**. For. Chron. 79(1): 132-146.
(We reviewed the published knowledge on forest succession in the North American boreal biome for its applicability in modelling forest cover change over large extents. At broader scales, forest succession can be viewed as forest cover change over time. Quantitive case studies of forest succession in peer-reviewed literature are reliable sources of information about changes in forest canopy cover change; timing of successional steps; probabilities of post-disturbance forest cover change; and effects of geographic location and ecological site conditions on forest cover change. In this paper, we outline an approach for incorporating published knowledge on forest succession into stochastic simulation models of boreal forest cover change in a standardized manner. We found that the lack of details in the literature on long-term forest succession, particularly on the influence of pre-disturbance forest cover composition, may be limiting factors in parameterizing simulation models. We suggest that simulation models based on published information can provide a good foundation as null models, which can be further calibrated as detailed quantitative information on forest cover change becomes available.)

(Zhou, X.), C. Peng, (Q. Dang), (J. Chen) and (S. Parton). 2003. **Simulating carbon dynamics of forest ecosystems in the Lake Abitibi Model Forest in Ontario**. Pp. 135-137 *in* Meeting Emerging Ecological, Economic, and Social Challenges in the Great Lakes Region: Popular Summaries. Buse, L. J. and A.H. Perera, comp. Sault Ste. Marie, ON, 9-11 June 2003. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 155. 206 p.
(This popular summary reports on the use of a new process-based forest growth and carbon dynamics model, TRIPLEX, to simulate forest growth and carbon dynamics at the forest stand level in the Lake Abitibi Model Forest.)

## Publications 2004

(Baldwin, D.J.B.), (K. Weaver), (F. Schnekenburger) and A.H. Perera. 2004. **Sensitivity of landscape pattern indices to input data characteristics on real landscapes: Implications for their use in natural disturbance emulation**. Landscape Ecol. 19(3): 255-271.
(Resource management strategies have begun to adopt natural landscape disturbance emulation as a means of minimizing risk to ecosystem integrity. Detailed understanding of the disturbance regime and the associated spatial landscape patterns are required to provide a "natural" baseline for comparison with the results of emulation strategies. Landscape pattern indices provide a useful tool to quantify spatial pattern for developing these strategies and evaluating their success. Despite an abundance of indices and tools to calculate these, practical knowledge of interpretation is rare. Quantifying changes in landscape pattern indices and the meaning of these changes is confounded by index sensitivity to input data characteristics such as spatial extent, spatial resolution, and thematic resolution. Sensitivity has been examined for simulated landscapes but rarely using real data for large areas as real landscapes are more difficult to manipulate systematically than simulated data. While simulated data offer a control, they do not provide an accurate portrayal of reality for practical applications. Our goal was to test the sensitivity of a suite of landscape pattern indices useful for disturbance emulation strategy development and evaluation to spatial extent, spatial resolution, and thematic resolution using current land cover data for a case study of the managed forest of Ontario, Canada. We also examined how sensitivity varies spatially across the study area. We used Landsat TM-based land cover data (> 45.5 million ha), controlling spatial extent (2,500 to 2,560,000 ha), spatial resolution (1 to 16 ha), and thematic resolution (2 to 26 classes). For each index we tested a hypothesis of insensitivity to changes in each input data characteristic using a combination of ANOVA and regression and compared our results with previous studies. Of the 18 indices studied, significant ($p < 0.01$) effects were found for 17 indices with changes in spatial extent, 13 indices with changes in spatial resolution, and 18 indices with changes in thematic resolution. A significant ($p < 0.01$) linear trend accounted for most of the variance for all of the significant relationships identified. Mean index responses were consistent with those interpreted from

previous studies of simulated and real landscapes; however, sensitivity varied greatly among indices and over space. We suggest that variation in sensitivity to input data characteristics among indices and over space must be explicitly incorporated in the design of future natural disturbance emulation efforts.)

(Bebber, D.P.), (S.C. Thomas), W.G. Cole and (D. Balsillie). 2004. **Diameter increment in mature eastern white pine *Pinus strobus* L. following partial harvest of old-growth stands in Ontario, Canada**. Trees 18(1): 24-34.
(Little is known about the responses of large, old trees to release from competition, though such trees are of great interest in forest ecology, conservation, and silviculture. Increment cores were taken from mature eastern white pines in 144 sample points in 12 partially harvested and 6 unharvested control stands in Ontario, Canada, to determine how these trees responded to a structural retention harvest that had occurred 9 years previously. Prior to harvest, increment growth was slightly lower in control stands, but not significantly so. Strong correlation in diameter increments among stands indicates external climatic forcing or internal synchronicity, e.g., reproductive allocation. Three years after harvest, growth in harvested stands overtook that in control stands, and increased to 63±8% SE above expected levels by 8 years after harvest. The study demonstrates the ability of old trees to respond markedly to reduced competition, questioning the concept of an age-related decline in forest productivity. In addition to increased timber production, growth responses of old trees have important implications for stand regeneration, wind firmness, and maintenance of wildlife habitat elements following partial stand harvests. Comparison of disturbed stands with undisturbed stands allows better estimation of tree responses than methods in which disturbance is inferred from diameter increment variation within individual trees.)

Bell, F.W. 2004. **Raith time by rate study**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. No. http // www.forestresearch.ca/partnership_projects/fibre_production/study_24.htm. 3 p.
(This popular summary presents 10 year results of 2 studies to determine the effects of glyphosate herbicide application rate and timing on control of (1) blue-joint grass and subsequent black spruce crop tree response and (2) red raspberry and subsequent jack pine crop tree response. For (1) the best combination of control and growth occurred for late August-early September applications and for (2) it was late July to early August applications. Glyphosate does not affect red raspberry seedbank so more than one application may be necessary.)

Bell, F.W., B. Parker and M. Park. 2004. **Wharncliffe study: Response of white pine to competition from fir, hazel, and fern**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. http://www.forestresearch.ca/partnership_projects/fibre_production/study_17.htm. 6 p.
(This popular summary presents 10 year results of a white pine additive species competition study in central Ontario. Results indicate that both natural and planted white pine respond favourably to competition control with best survival and growth occurring when multiple species are removed. For example, stem volume of natural pine was 40 times higher in competition-free plots than plots with a combination of fir, hazel, and bracken fern. Fir and hazel are more competitive with pine than bracken fern.)

Bell, F.W. and J.A. Winters. 2004. **Fallingsnow Ecosystem Project: White spruce and vegetation responses**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. http://www.forestresearch.ca/partnership_projects/fibre_production/study_21.htm. 5 p.
(This popular summary presents 7 year results of a spruce competition control study comparing herbicides and cutting treatments in boreal Ontario. Overall, herbicides were more effective than cutting and within cutting treatments the Silvana Selective mechanical brush cutter was more effective than brush saw treatments for releasing spruce plantations. Spruce height and diameter growth was optimized on the aerial herbicide treated plots.)

Bell, F.W. and M.C. Wester. 2004. **Jack pine growth responses to alternative vegetation management 10 years after treatment**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. http://www.forestresearch.ca/partnership_projects/fibre_production/study_20.htm. 6 p.
(This popular summary presents 10-year response of jack pine to herbicide and brush saw release treatments in boreal Ontario. Early response patterns persist with jack pine volume inversely related to the amount of competition present. Difference between multiple and single competition control treatments not as evident as differences between herbicide and cutting and cutting and control, with treatment effectiveness in that order.)

Bell, F.W., (M. McLaughlan) and (J. Kerley). (comp.). 2004 rel. **Vegetation management alternatives: A guide to opportunities**. Ont. Min. Nat. Resour., Northw. Sci. Inf., Thunder Bay, ON. Binder.
(This binder contains a series of 14 technical notes that synthesize the available knowledge on vegetation management approaches and alternatives for resource managers. This product is intended as a tool to aid in developing integrated vegetation

management strategies and can be used by resource managers as a quick reference guide to answer questions from the public. Notes in the guide cover a range of topics including silvicultural systems -- clearcutting, shelterwood, and selection silvicultural systems as related to vegetation management; harvesting considerations -- implications of harvesting practices for vegetation management and cut stump herbicides treatments; forest renewal -- prescribed fire, mechanical site preparation, and regeneration strategies for vegetation management; and stand maintenance -- herbicides; fungi and plant toxins; manual, motor-manual and mechanical cutting; and grazing animals as vegetation management tools.)

Bell, F.W. and M. Park. 2004. **Relative competitiveness of nine early successional boreal forest species associated with planted jack pine and black spruce seedlings**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. http://www.forestresearch.ca/partnership_projects/fibre_production/study_14.htm. 3 p.
(This popular summary presents 7 year results of an additive density competition study with 2 conifers planted on 3 soil types in combination with various densities of 9 competitive species. Overall, as density of competitors increased, volume of jack pine and black spruce decreased. Effects of herbaceous competition was greater than that of woody competition for pine but the opposite was true for spruce.)

Colombo, S.J. 2004. **How to improve the quality of broadleaved seedlings produced in tree nurseries**. Pp. 41-53 *in* Nursery Production and Stand Establishment of Broad-Leaves to Promote Sustainable Forest Management. L. Ciccarese, S. Lucci and A. Mattsson, eds. Rome, Italy, May 7 - 10, 2001. Agency for Environmental Protection and Technical Services. 285 p.
(Broadleaved seedlings grown in tree nurseries contribute to forest sustainability in 3 ways. First, commercial plantations established from nursery stock provide wood products used by society and associated economic benefits. Secondly, seedlings used to establish community forests support the need for wood that is consumed locally or is manufactured and sold to the direct benefit of those in the community. Thirdly, broadleaved nursery stock production can also promote forest sustainability by conserving local genetic sources of indigenous species that might otherwise be lost. Producing nursery stock of a desired size requires balancing environment conditions between those favouring growth and those which hold growth back, while avoiding severe infestations by harmful insects and disease. Nursery stock needs to meet certain size targets to be successful after planting, however, physiological properties are at least equally important to field performance. Nonetheless, practices to produce seedlings possessing desirable physiological traits remain beyond the reach of most nursery managers. Physiological criteria of stock quality are available but their adoption as grading standards seldom occurs without the support of those who are responsible for tree survival after planting. The development of morphological and physiological standards that are based on field performance and related back to nursery production practices is an important element of the improvement of reforestation success using broadleaved tree species.)

(Crow, T.R.) and A.H. Perera. 2004. **Emulating natural landscape disturbance in forest management -- an introduction.** Landsc. Ecol. 19: 231-233.
(This is a brief introduction to a special issue of the journal Landscape Ecology that includes papers presented at a 2004 IUFRO workshop focussed on emulating natural forest landscape disturbance (ENFD) in the Great Lakes region of North America. The broad goal of ENFD is outlined and a summary of papers in the issue is provided, including their relevance to ENFD and management.)

DeYoe, D. and (C. Hollstedt). 2004. **A knowledge exchange system: Putting innovation to work**. BC J. Ecosyst. Manage. 4(1): 1-10.
(Effective and efficient application of new knowledge and technology in Canada's forest sector continues to challenge both government and industry. This impedes the development of government policy and advancement in private sector diversification and productivity growth. This paper outlines a knowledge exchange system by which researchers and customers in government and industry can achieve desired business outcomes through the optimal development and application of innovative approaches. The system integrates 3 major functions: knowledge generation, knowledge exchange, and knowledge application. The importance of extension professionals is highlighted as a critical link in helping to ensure that new knowledge and innovative technologies are put into practice. Nine knowledge system elements are introduced and the role of each in bridging the research-to-operations gap is described.)

Johnson, J., (A. Morneault) and F.W. Bell. 2004. **Alternatives to aerial tending in jack pine plantations**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. http://www.forestresearch.ca/partnership_projects/fibre_production/study_19.htm. 6 p.
(This popular summary presents 10-year response of jack pine plantations to vegetation management

treatments including aerial herbicide, ground herbicide, basal bark, and brushsaw in central Ontario. Crop tree response was maximized by a single aerial spray, which was as effective as 3 years of consecutive competition control in this study. Unlike many other studies reported, in this study response patterns to the various treatments continue to change.)

Lu, P. and B. Sinclair. 2004. **Protecting eastern white pine from blister rust**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. Fact sheet 2 p.
(This fact sheet provides an overview of the disease white pine blister rust, it's effects on white pine, and research being undertaken by OFRI's forest genetics program to minimize associated damage to white pine seedlings.)

Lu, P. and (T.L. White). 2004. **Determining test and block numbers in consideration of progeny testing quality and cost: An example of half-sib families with RCB design and single-tree plots**. For. Genet. 11(1): 27-42.
(Cost-effective test and block numbers for tree progeny testing using randomized complete block designs (RCB) with single-tree plots were investigated through a generalization of the relationships between progeny testing quality criteria and test design parameters. Optimal test and block numbers were defined as those that achieve an adequate level of testing quality using the minimum resources. Results indicated that the desirable test and block numbers were functions of the target quality criteria, genetic architecture of a character and costs associated with each additional test site. A trait with low heritability and strong G x E interaction generally required a larger number of test sites than one with high heritability and weak G x E interaction to reach the same level of testing quality. Higher cost for each additional site favored using fewer test sites and more blocks per site. A testing quality standard higher than 90 % in the reliability of breeding value prediction consumed substantially more resources than one of 75-85%. Desirable test and block numbers were provided to satisfy different progeny testing quality requirements under various scenarios of genetic architecture of a trait and the cost associated with each additional site.)

MacDonald, G.B. and J.A. Rice. 2004. **An active adaptive management case study in Ontario boreal mixedwood stands**. For. Chron. 80(3): 391-400.
(Active adaptive management has recently been advocated for efficiently reducing resource management uncertainties, but no documented applications to forestry issues exist in Ontario. This paper reports the experience of a diverse partnership applying active adaptive management to improve techniques for obtaining desired boreal mixedwood structure and composition in northeastern Ontario. Institutional and economic barriers have been more limiting than technical barriers. Building and maintaining the partnership have required considerable effort, and opportunities for conflict were greatest in the assessment and design steps of the adaptive management cycle. The partnership has maintained its progress by promoting flexibility, trust, and consensus-building. This study demonstrates that classical adaptive management can be simplified for application in local management units. A broader application of active adaptive management in Ontario will require senior decision-makers to endorse a strategy that includes staff retraining, admission of management uncertainties, cooperation among management agencies, stability of long-term funding, encouragement of innovation, and regular adjustment of policies and practices.)

MacDonald, G.B., M.L. Cherry and D.J. Thompson. 2004. **Effect of harvest intensity on development of natural regeneration and shrubs in an Ontario boreal mixedwood stand**. For. Ecol. Manage. 189(2): 207-222.
(Resource managers in northern Ontario need guidelines for establishing productive species mixtures and maintaining a viable conifer component through natural regeneration on upland boreal mixedwood (BMW) sites. The hypothesis that partial cutting favours conifers by inhibiting development of hardwood reproduction and associated competitors was tested. Harvesting to nominal basal area (BA) reductions of 0, 36, 68, and 100% was conducted in a northeastern Ontario mixedwood stand dominated by trembling aspen in the overstory and balsam fir and shrubs in the understory. A positive linear relationship existed between photosynthetically active radiation (PAR) transmittance and initial BA reduction at 1, 3, and 5 years after harvesting. However, the relationship weakened over the 4-year period. Although BA reduction level did not account for significant variation in height growth of conifer advance regeneration, it explained 31% of the variation in conifer sapling diameter growth, 61% of the variation in hardwood regeneration height growth, and 21% of the variation in shrub height growth. Based on post-harvest height comparisons among conifers, hardwoods, and shrubs, partial cutting to promote conifer advance regeneration on BMW sites cannot be recommended. Maintaining a viable understory of shade-tolerant conifers for the next rotation may be more feasible than promoting conifer–hardwood overstories in the current rotation. The increase in sapling growth with BA reduction

level implies that the entire overstory should be removed if the site is adequately stocked with conifer saplings. Similarly, harvesting should remove the entire overstory if the objective is to maximize growth of hardwood regeneration. Clearcutting promoted growth of both hardwood crop trees and shrubs, but hardwoods remained dominant after 5 years. Height development patterns indicate that regeneration and competitors should be monitored long enough following harvesting to determine whether additional interventions may be necessary to achieve stand structure objectives. Further studies are required to investigate the effects of other factors on advance regeneration, such as pattern and season of harvest and degree of soil disturbance.)

McLaughlin, J.W. 2004. **Carbon assessment in boreal wetlands of Ontario**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 158. 79 p.

(This report complements existing wetland carbon (C) reviews by focusing on the interactions between vegetation and hydrology and their effects on regulating peatland C cycling and budgets at both local and regional scales in the boreal zone of Ontario. The report presents and discusses information and suggests areas of research that span multiple spatial and temporal levels related to uncertainties in peatland C cycling. It summarizes the state-of-the-knowledge in peatland C dynamics, identifies critical research gaps, and presents research that is currently being conducted (but in its infancy) to improve the ability to assess C in Ontario's peatlands. Information from the report can be used to help define the role of Ontario's peatlands in national and global C cycles and budgets.)

Noland, T.L. and (G.H. Mohammed). 2004. **Competition tolerance of bareroot and container seedlings of jack pine, white pine, and black spruce ten years after planting**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. http://www.forestresearch.ca/partnership_projects/fibre_production/study_15.htm. 4 p.

(This popular summary presents results of container and bareroot conifers with and without vegetation control relative to preplant morphological characteristics. Ten year trends are similar to those reported at year five. More competitive jack pine seedlings had lower height:diameter ratio and more lateral roots at planting and more competitive white pine had larger root systems at planting. Black spruce performance did not seem to be correlated with preplant morphological characteristics.)

Obenchain, A.M. (ed.). 2004. **Insights**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. 6 (2). 16 p.

(This issue of OFRI's newsletter includes an update on ice damage research, climate change research, jack pine root cutting work, the BFOLDs model, new research highlights including stream monitoring, use of large-scale photography for forest inventory, growing yew for cancer drugs, and summaries of new publications.)

Parker, W.C. 2004. **Rehabilitation of Great Lakes-St. Lawrence conifer forests: The effect of mechanical site preparation on growth and survival of white pine and white spruce nursery stock**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. http://www.forestresearch.ca/partnership_projects/fibre_production/study_5.htm. 4 p.

(This popular summary presents results of planted white spruce and white pine survival and growth response to various site preparation treatments in central Ontario. Site preparation effects were ranked based on percent mineral soil exposure (ranged from 10 to 84%). Five years post-planting, white pine survival was much lower than that of white spruce (ranged from 11 to 47% vs. 69 to 92%) likely due to lower tolerance to vegetative competition as well as blister rust damage on the more open raked areas. Where white pine survived, volume was higher than that of white spruce.)

Parker, W.C., T.L. Noland and (A.E. Morneault). 2004. **Effect of seed mass on early seedling growth of five eastern white pine (*Pinus strobus* L.) families under contrasting light environments**. Can. J. Bot. 82 (11). 1645-1655.

(The strong influence of seed mass on early seedling growth of forest tree species is well established, but the ecological role of intraspecific variation in seed mass on natural regeneration is poorly understood. Wide variation in initial spatial patterns of natural regeneration of eastern white pine between managed and undisturbed white pine forests of the Great Lakes region of North America has been attributed to differences in understory light levels and the frequency of substrates suitable for germination and seedling establishment. To explore the potential influence of seed mass on these observed patterns, the interaction of seed mass and light on early growth of white pine was investigated in a greenhouse study. Seedlings of 5 half-sib families differing in mean seed mass were grown for 8 and 14 weeks under moderate and low light conditions representing managed and undisturbed pine stands, respectively. Family differences in seedling biomass and root system development under each light environment were associated with positive, linear relationships with mean seed mass. Family and seed mass had a comparatively weak influence on biomass partitioning and relative growth rate. Moderate light improved

seedling growth regardless of seed mass, but relative expression of seed mass effects on seedling traits was unaffected by light environment. These results suggest differential recruitment of white pine in managed and undisturbed stands is unrelated to variation in seed mass.)

Peng, C., (L. Zhang), (X. Zhou), (Q. Dang) and (S. Huang). 2004. **Developing and evaluating tree height-diameter models at three geographic scales for black spruce in Ontario**. North. J. Appl. For. 21(2): 83-92.
(A total of 11,612 black spruce trees were measured from permanent sample plots across the boreal and central regions of Ontario and were used to fit the well-known Chapman-Richards growth model at provincial, regional, and ecoregional scales. The results suggest that the height-diameter relationships of black spruce vary with different geographic regions and scales. There were significant variations in height-diameter relationships for black spruce between boreal and central regions as well as among some of the seven ecoregions. The ecoregion-based height-diameter models presented here will provide more accurate predictions for tree height and, consequently, tree volume than these models developed at both provincial and regional scales. Furthermore, the heterogeneity of tree species should be considered in developing and applying ecoregion-based height-diameter models for predicting local tree height.)

Perera, A.H., (D. Yemshanov), F. Schnekenburger, D.J.B. Baldwin, (D. Boychuk) and (K. Weaver). 2004. **Spatial simulation of broad-scale fire regimes as a tool for emulating natural forest landscape disturbance**. Pp. 112-122 *in* Emulating Natural Forest Landscape Disturbances: Concepts and Applications. Perera, A. H., L.J. Buse and (M.G. Weber), eds. Columbia University Press, New York, NY. 315 p.
(This chapter presents a spatially explicit stochastic simulation modelling method and demonstrates its use for quantifying broad-scale natural fire disturbance regimes in the boreal forest. The Boreal Forest Landscape Dynamics Simulator (BFOLDS) used in this case study is described and results of simulation runs provided.)

Perera, A.H. and L.J. Buse. 2004. **Action plan for scientific studies to assess the effectiveness of the directions in the Forest Management Guide for Natural Disturbance** (v. 3.1). Ont. Min. Nat. Resour., Sault Ste. Marie, ON. Unpubl. Rep. 15 p.
(The Forest Management Guide for Natural Disturbance Pattern Emulation provides guidance for emulating fire patterns using landscape harvest patterns and structural legacy, as captured by specific directions about clearcut size patterns, separation criteria for planned cuts, residual patches, and residual trees. The ecological foundation for these directions was examined by reviewing the published knowledge on fire disturbance patterns. In doing so, the degree of knowledge uncertainty associated with the directions was determined, and relevant scientific questions formulated to reduce these knowledge uncertainties. The broad scientific study groups proposed in this action plan address these questions with the intent of developing new and reliable knowledge related to the 4 directions at a nested hierarchy of spatial scales, within a 3-year period beginning in April 2005 and ending in April 2008, including reporting mechanisms to ensure that the progress of scientific studies is monitored and new knowledge is made available for future guide revisions.)

Perera, A.H. and L.J. Buse. 2004. **Emulating natural disturbance in forest management: An overview**. Pp. 3-7 *in* Emulating Natural Forest Landscape Disturbances: Concepts and Applications. Perera, A. H., L.J. Buse and M.G. Weber, eds. Columbia University Press, New York, NY. 315 p.
(This chapter introduces the concept of emulating natural disturbance in forest management and poses questions about what can be emulated and what the expectations of disturbance emulation might be by way of introduction to a book on the subject.)

Perera, A.H., L.J. Buse and (M.G. Weber). (eds.). 2004. **Emulating Natural Forest Landscape Disturbances: Concepts and Applications.** Columbia University Press, New York, NY. 352 p.
(What is a natural forest disturbance? How well do we understand natural forest disturbances and how might we emulate them in forest management? What role does emulation play in forest management? Representing a range of geographic perspectives from across Canada and the United States, this book looks at the escalating public debate on the viability of natural disturbance emulation for sustaining forest landscapes from the perspective of policymakers, forestry professionals, academics, and conservationists. The first section examines foundational concepts, addressing questions of what emulation involves and what ecological reasoning substantiates it. The second section uses case studies from a wide geographical range to address the characterization of natural disturbances and the development of applied templates for their emulation through forest management. The final section moves deeper into the issues of practical applications by exploring the expectations for and feasibility of emulating natural disturbance through forest management.) *(Not available from OFRI – order directly from publisher or distributor.)*

Perera, A.H., L.J. Buse, (M.G. Weber) and (T.R. Crow). 2004. **Emulating natural forest landscape disturbances: A synthesis**. Pp. 265-274 *in* Emulating Natural Forest Landscape Disturbances: Concepts and Applications. Perera, A.H., L.J. Buse and M.G. Weber, eds. Columbia University Press. New York. NY. 315 p.
(This chapter presents a synthesis of the state of knowledge about emulating natural disturbance in northern North America and provides a view of the future of this forest management approach. Information from other chapters in the book are summarized to describe what natural disturbance emulation is, why one might do it, methods of understanding disturbances, and practical approaches to implementing this concept. As well, future needs critical to the success of implementing the emulation of natural disturbance in forest management are highlighted.)

Perera, A.H., L.J. Buse and R.G. Routledge. 2004. **An analysis of literature on natural fire disturbances in relation to Ontario's Forest Management Guide for Natural Disturbance Pattern Emulation**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie. ON. For. Res. Inf. Pap. No. 159. 62 p.
(Ontario's Forest Management Guide for Natural Disturbance Pattern Emulation (NDPE v. 3.1, 2002) provides direction for emulating natural fire disturbances in forest management planning. We examined the North American scientific literature on natural fire disturbances in relation to the directions in this guide for (1) landscape harvest size patterns, (2) landscape harvest patch separation, (3) residual stands, and (4) residual trees and downed woody debris. An associated trend analysis, annotated bibliography, and list of related references are provided. Publications on natural fire disturbances are abundant, with an exponential increase after 1990, focusing mainly on stand-replacing fires in boreal forests. Literature related to NDPE Guide directions constitutes 37% of the publications, most becoming available since the development of the guide. In spite of the abundance of literature related to natural fire disturbances, many gaps exist in the published knowledge, especially on the spacing of burned patches. As well, the potential variability in fire regimes is not captured adequately because most studies were based on analyses of historical fire data. Reports on simulation studies that can capture sources of variability in fire regimes are just beginning to emerge. Variability associated with post-fire residual patches is not adequately addressed in the literature, and less information is available about peninsular residuals than insular residuals. Although many publications on post-fire residual trees and downed woody debris have been published in the last 5 years, this information is often based on studies of single fires. As a result, knowledge of post-fire residuals and their causal factors cannot be generalized. Overall, the published knowledge is not adequate to understand the stochasticity and variability in spatial patterns of fires and post-fire residuals associated with fire regimes in boreal and near-boreal forests.)

(Pinto, F.), (S. Vasiliauskas), (A. Morneault), (S. McPherson), (D. Othmer) and F.W. Bell. 2004. **Site preparation for white pine restoration: Mattawa**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. http://www.forestresearch.ca/partnership_projects/fibre_production/study_22.htm. 6 p.
(This popular summary presents results of site preparation and tending treatments on the establishment and growth of white pine regeneration on a mixedwood site in central Ontario. While all treated plots were well stocked to white pine 7 years after the treatments, few were likely to become white pine dominated. Instead, much of the fibre was poplar. Young's teeth increased shrub cover while chemical site preparation increased grass cover but none of the treatments eliminated competition nor were any plant forms or structural layers eliminated.)

(Pitt, D.G.) and F.W. Bell. 2004. **Effects of stand tending on the estimation of aboveground biomass of planted juvenile white spruce**. Can. J. For. Res. 34(3): 649-658.
(Stem, branch, needle, and total aboveground biomass were assessed for 3 9- to 12-year-old white spruce plantations, each subjected to 3 different stand tending options at age 4 to 7. Biomass components were predicted from measures of stem diameter with coefficients of variation between 24% and 29%. Diameter at breast height (DBH) generally provided lower prediction precision than did the lower stem measures tested (coefficient of variation > 35%). The addition of tree height in models reduced the standard error of the estimates for stem and total biomass by an average of 48% and 8%, respectively, and compensated for different height/diameter ratios imposed on the spruce by the stand tending treatments. Needle and branch biomass models were invariant to the tending treatments and, consequently, to the addition of height as an independent variable. Predictions from existing published white spruce equations suggest that extrapolation to this study area would have led to adequate stem biomass estimation but to serious (>55%) underestimates of branch, needle, and, correspondingly, total biomass. Slow self-pruning by plantation spruce, particularly before crown closure, is cited as a possible reason for these differences.)

(Rouault, G.), (J. Turgeon), J.-N. Candau, (A. Roques) and (P. von Aderkas). 2004. **Oviposition strategies of conifer seed chalcids in relation to host phenology**. Naturwissenschaften 91(10): 472-480.
(The morphological stage of cone development at the time of oviposition by seed chalcids has been established for many species; however, knowledge of ovule development at that time has been documented for only one species, *Megastimus. spermotrophus*. *M. spermotrophus* oviposits in Douglas-fir ovules after pollination but before fertilization. Unlike the unfertilized ovules, those containing a *M. spermotrophus* larva continue to develop, whether fertilized or not, stressing the need to broaden our understanding of the insect–plant interactions for this entire genus. We reviewed the scientific literature and assembled information about the timing of oviposition and the pollination and fertilization periods of their respective host(s). More specifically, we were searching for circumstantial evidence that other species of *Megastigmus* associated with conifers could behave (i.e., oviposit before ovule fertilization) and affect female gametophyte (i.e., prevent abortion) in the same way. Evidence suggests that seed chalcids infesting Pinaceae may also oviposit before ovule fertilization, just like *M. spermotrophus*, whereas those infesting Cupressaceae seemingly oviposit after ovule fertilization. Based on this evidence, we hypothesize that all species of *Megastigmus* associated with Pinaceae can oviposit in unfertilized ovules, whereas those exploiting Cupressaceae oviposit only in already fully developed fertilized seeds. Furthermore, we predict that the presence of a larva in unfertilized ovules of all Pinaceae will influence the development of the female gametophyte by preventing its abortion. This influence on the Pinaceae can be interpreted as an ability to parasitize any of the potential seeds present in a seed cone, and as such represents a much more efficient oviposition strategy than searching and locating only fertilized seeds. Concomitantly, this ability has likely led to an overestimation of the impact of the species of seed chalcid infesting Pinaceae on seed production.)

(Suffling, R.) and A.H. Perera. 2004. **Concepts and approaches in characterizing natural forest disturbance regimes.** Pp. 43-54 *in* Emulating Natural Forest Landscape Disturbances: Concepts and Applications. Perera, A.H., L.J. Buse and M.G. Weber, eds. Columbia University Press, New York, NY. 315 p.
(This chapter presents basic components of natural forest disturbance regimes including drivers, causal agents, and scale as well introducing the idea of spatial and temporal variability, both of which need to be considered in order to emulate disturbance. Possible approaches for characterizing disturbance regimes are introduced.)

Ter-Mikaelian, M.T., W.T. Zakrzewski, G.B. MacDonald and (D.H. Weingartner). 2004. **Stem profile equations for young trembling aspen in northern Ontario**. Ann. For. Sci. 61(2): 109-115.
(Stem profile equations were developed for young trembling aspen growing on 6 different sites in northern Ontario. The objective was to develop a model using stem diameter at any height to predict stem diameter at other heights and then compare the model among sites. The 262 sample trees were split into calibration (180) and validation (82) sets. Four stem profile models having from 1 to 3 parameters were tested for parameter significance for each site, and then compared among sites. Data analysis was performed using bootstrap methods. One of the 4 models was not significantly different ($P > 0.278$) among sites. Validation of this model produced mean prediction errors and mean relative prediction errors of less than 0.001 cm and 0.09%, respectively; standard deviations of these errors were 0.15 cm and 4.09%, respectively. The presented method can be used to develop stem profile equations that are applicable to a broad range of growing conditions.)

(Wagner, R.G.) and T. Noland. 2004. **Critical period for controlling competing vegetation in jack pine, red pine, white pine, and black spruce plantations: 10-year results**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. http://www.forestresearch.ca/partnership_projects/fibre_production/study_16.htm. 6 p.
(This popular summary presents 10 year results of critical period competition study of 4 conifers. Ten year results were similar to those reported after 5 years, suggesting that early responses to vegetation control are persisting until crown closure. Decreases in volume production with increasing duration of competition after planting were similar among conifer species. While jack pine and red pine benefitted most from competition control for 2 to 3 years post-planting, white pine and black spruce required 4 to 5 years of consecutive vegetation control to achieve maximum production.)

(Weaver, K.) and A.H. Perera. 2004. **Modelling land cover transitions: A solution to the problem of spatial dependence in data**. Landscape Ecol. 19(3): 273-289.
(Raster-based spatial land cover transition models (LCTMs) are widely used in landscape ecology. However, many LCTMs do not account for spatial dependence of the input data, which may artificially fragment the output spatial configuration. We demonstrate the consequences of ignoring spatial

dependence, thus assigning probabilities randomly in space, using a simple LCTM. We ran the model from 4 different initial conditions with distinct spatial configurations and results indicated that, after 20 simulation steps, all of them converged towards the spatial configuration of the random data set. From an ecological perspective this is a serious problem because ecological data often exhibit distinct spatial configuration related to ecological processes. As a solution, we propose an approach (region approach) that accounts for spatial dependence of LCTM input data. Underlying spatial dependence was used to apply spatial bias to probability assignment within the model. As a case study we applied a region approach to a Vegetation Transition Model (VTM); a semi-Markovian model that simulates forest succession. The VTM was applied to approximately 500,000 ha of boreal forest in Ontario, at 1 ha pixel resolution. When the stochastic transition algorithms were applied without accounting for spatial dependence, spatial configuration of the output data became progressively more fragmented. When the VTM was applied using the region approach to account for spatial dependence, output fragmentation was reduced. Accounting for spatial dependence in transition models will create more reliable output for analyzing spatial patterns and relating those patterns to ecological processes.)

Wester, M.C. and F.W. Bell. 2004. **Fourteen-year performance of three conifer stock types treated with hexazinone**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. http://www.forestresearch.ca/partnership_projects/fibre_production/study_12.htm. 3 p.
(This popular summary presents results of jack pine and black spruce growth following 4 hexazinone site preparation treatments on coarse soils in boreal Ontario. Overall, crop tree growth increased with increasing herbicide concentration and was higher for crop trees planted one month following treatments than those planted a year later, except for bareroot black spruce for which deferring planting did not seem to have any effect on growth performance.)

Winters, J.A. and F.W. Bell. 2004. **Early glyphosate studies in northeastern Ontario**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. http://www.forestresearch.ca/partnership_projects/fibre_production/study_23.htm. 10 p.
(This popular summary presents longer-term (20 to 25 years post) results of 4 early glyphosate release studies in boreal Ontario. In general, effects of glyphosate are still evident 20 years after application resulting in conifer-dominated stands but species diversity is maintained. Increasing the rate does not always provide better competition control. A combination of site preparation and soon after planting glyphosate application allows crop species (black and white spruce and jack pine) to become established.)

Winters, J.A. and F.W. Bell. 2004. **The effect of site preparation on the growth of jack pine, black spruce, and white spruce**. For. Res. Partnership, Mattawa, ON. Unpubl. Sum. http://www.forestresearch.ca/partnership_projects/fibre_production/study_4.htm. 4 p.
(This popular summary presents 15 year results of a site preparation study on 2 sites near Foleyet, Ontario. Windrowing, trenching, chopping, crushing, and herbicide, alone and in combination were tested. Overall, crop tree survival was poor, especially for jack pine, likely due to early herbaceous competition. In general, mechanical site preparation resulted in better survival and volume growth than herbicide site preparation.)

Zakrzewski, W.T. 2004. **Non-regression approach to defining a stem profile model**. Pp. 127-131 *in* Northeastern Mensurationist Organization and Southern Mensurationists 2003 Joint Conference. Doruska, P.F. and P.J. Radtke, comp. Raonoke, VA, 6-7 Oct 2003. Virginia Tech Dept. For.
(This note provides an overview of the development and testing of a taper model calibrated for pine species. The model produced reasonable predictions for both tree volume and diameter of the sample species. In general the method may be useful for most practical applications involving taper models but better predictions are possible using a 2-coefficient model.)

(Zarco-Tejada, P.-J.), (J.R. Miller), (J. Harron), (B. Hu), T.L. Noland, (N. Goel), (G.H. Mohammed) and (P. Sampson). 2004. **Needle chlorophyll content estimation through model inversion using hyperspectral data from boreal conifer forest canopies.** Remote Sens. Environ. 89(2): 189-199.
(Leaf chlorophyll content in coniferous forest canopies, a measure of stand condition, is the target of studies and models linking leaf reflectance and transmittance and canopy hyperspectral reflectance imagery. The viability of estimation of needle chlorophyll content from airborne hyperspectral optical data through inversion of linked leaf level and canopy level radiative transfer models is discussed in this paper. This study is focused on 5 jack pine sites in the Algoma Region (Canada), where field, laboratory, and airborne data were collected in 1998 and 1999 campaigns. Airborne hyperspectral CASI data of 72 bands in the visible and near-infrared region and 2 m spatial resolution were collected from 20 × 20 m study sites of jack pine in 2 consecutive

years. It was found that needle chlorophyll content could be estimated at the leaf level ($r^2$=0.4) by inversion of the PROSPECT leaf model from needle reflectance and transmittance spectra collected with a special needle carrier apparatus coupled to the Li-Cor 1800 integrating sphere. The jack pine forest stands used for this study with LAI > 2, and the high spatial resolution hyperspectral reflectance collected, allowed the use of the SPRINT canopy reflectance model coupled to PROSPECT for needle chlorophyll content estimation by model inversion. The optical index R750/R710 was used as the merit function in the numerical inversion to minimize the effect of shadows and LAI variation in the mean canopy reflectance from the 20 × 20 m plots. Estimates of needle pigment content from airborne hyperspectral reflectance using this linked leaf-canopy model inversion methodology showed an $r^2$=0.4 and RMSE=8.1 g/cm$^2$ when targeting sunlit crown pixels in jack pine sites with pigment content ranging between 26.8 and 56.8 g/cmg/g).)

(Zhang, L.), C. Peng and (Q. Dang). 2004. **Individual-tree basal area models for jack pine and black spruce in northern Ontario**. For. Chron. 80(3): 366-374.
(Individual-tree models of 5-year basal area growth were developed for jack pine and black spruce in northern Ontario. Tree growth data were collected from long-term permanent plots of pure and mixed stands of both species. Models were fitted using mixed model methods due to correlated remeasurements of tree growth over time. Since the data covered a wide range of stand ages, stand conditions and tree sizes, serious heterogeneous variances existed in the data. Therefore, the coefficients of the final models were obtained using weighted regression techniques. Models for both species were evaluated across 4-cm diameter classes using independent data. The results indicated (1) models of jack pine and black spruce produced similar prediction errors and biases for intermediate-sized trees (12 to 28 cm in diameter), (2) both models yielded relatively large errors and biases for larger trees (>28 cm) than those for smaller trees, and (3) the jack pine model produced much larger errors and biases for small trees (<12 cm) than did the black spruce model.)

(Zhou, X.), C. Peng and (Q. Dang). 2004. **Assessing the generality and accuracy of the TRIPLEX model using in situ data of boreal forests in central Canada**. Environ. Model. Software 19(1): 35-46.
(TRIPLEX1.0 is a hybrid model that integrates 3 well-established process models including 3-PG, TREEDYN3.0, and CENTURY4.0. We have conducted calibrations using data from 8 sites to determine and generalize TRIPLEX parameters. We also performed model validation using 66 independent data sets to examine model accuracy and application. Simulations were conducted for plots with large sample size from the boreal ecosystem atmosphere study (BOREAS) program, including the northern study area (NSA) near Thompson, Manitoba (55.7° N, 97.8° W) and the southern study area (SSA) near Prince Albert, Saskatchewan (53.7° N, 105.1° W). Calibrations and simulations emphasized generating average parameters and initial status for applying a complex model in a broad region where detailed site information, such as photosynthetic capacity, soil carbon, nutrients, soil water, and tree growth, is not always available. A suggestion was presented for adjusting the sensitivity parameter by estimating tree growth rate corresponding to different site conditions. The study actually presented a reasonable and balanced parameter generalization procedure that did not significantly reduce model accuracy, but did increase model practicability. Observations and simulation results were similar for tree density, mean tree height, DBH, soil carbon, aboveground and total biomass, net primary productivity (aboveground), and soil nitrogen for both short- and long-term simulations. Results presented here imply that the set of parameters generalized and suggested in this study can be used as basic reference values and that TRIPLEX can be applied to simulate the general site conditions of boreal forest ecosystems.)

(Zhou, X), C. Peng, (Q. Dang), (J. Chen) and (S. Parton). 2004. **Simulating forest growth and carbon dynamics of the Lake Abitibi Model Forest in northeastern Ontario**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Rep. No. 163. 20 p.
(This study assessed the temporal and spatial variability in forest growth and carbon storage to provide a comprehensive estimate of the carbon budget for boreal ecosystems in the Lake Abitibi Model Forest (LAMF) in Ontario. In this study, we simulated the stand-level growth and carbon dynamics for the LAMF using a new process-based forest growth and carbon dynamics model, TRIPLEX1.0 and GIS (Geographic Information System). The model was recently calibrated and tested using field measurements collected in Ontario and from the BOREAS study area in central Canada. The model was validated using 49 permanent sample plots (PSP) collected in the LAMF. Simulated breast height tree diameters (DBH) are close to those measured from local PSPs. Simulated carbon storage, i.e., net primary productivity (NPP), forest

biomass, and soil carbon, were compared with field data and results from other studies for Canada's boreal forests. The results show that the NPP of the LAMF ranged from 3.26 to 3.34 t C $ha^{-1}yr^{-1}$ in the 1990s and was sensitive to changes in annual temperature and precipitation. The NPP values were consistent with values measured during the Boreal Ecosystem-Atmosphere Studies in central Canada. The density of total above- and belowground biomass was 125.3, 111.8, and 106.5 t C $ha^{-1}$ for black spruce, trembling aspen, and jack pine, respectively. The total carbon density of forested land was estimated at 154.4 (t C $ha^{-1}$) with a ratio of 4:6 for total biomass and soil. Estimates of carbon based on stand variables (tree age, species, soil type, and site class) and analysis of the net carbon balance suggest that the LAMF forest ecosystem was acting as a carbon sink in the 1990s. These results provide information needed by local forest managers to develop ecological and carbon-based indicators and monitor the sustainability of their forest ecosystems.)

## Publications 2005

(Bebber, D.P.), W.G. Cole, (S.C. Thomas), (D. Balsillie) and (P. Duinker). 2005. **Effects of retention harvests on structure of old-growth *Pinus strobus* L. stands in Ontario**. For. Ecol. Manage. 205(1): 91-103.
(Retention of structural elements, or legacies, of old-growth stands at harvest has been proposed as a means of maintaining wildlife habitat and ecosystem function in managed forests. However, little is known of the effects and consequences of such practices on the residual stand. A "structural retention harvest" of old-growth eastern white pine was carried out in 1992 in the Algoma Forest of central Ontario, Canada. In contrast to then–current guidelines, declining- and cavity-trees, snags and coarse woody debris (cwd) were retained at harvest. Cut and uncut stands were surveyed in 2001 to determine the effects of this harvest on forest structure. Basal area prism sweeps for trees and snags were taken at 100 m spacing in 12 logged and 6 unlogged stands in August 2001. Ground cover, regeneration, and cwd were recorded. White pine basal area before harvest varied among stands from 4.5 to 25.7 $m^2$ $ha^{-1}$, or 21–68% of stand total. No white pine trees below 18 cm dbh were found. Around half of white pine basal area was removed at harvest. Logging damage was found on 7% of residual white pines. Harvested stands had similar numbers of cavity trees, standing snags, and volume of natural-origin cwd, to unharvested stands. Inputs of logged white pines left in situ increased the total volume of cwd in harvested stands compared with unharvested stands. Harvested stands also contained more recently dead pines and tip-over trees than unharvested stands. White pine regeneration was scarce, though marginally greater in cut stands. Regeneration was correlated with increased canopy openness in cut stands. Herbaceous cover and sapling density was greater in harvested stands. The study shows that structural retention harvesting can maintain or exceed levels of habitat provision such as cavity trees and cwd, found in old stands, though increased tree mortality and wind-throw can result.)

Boivin, J., J.-N. Candau, J. Chen, S. Colombo and M. Ter-Mikaelian. 2005. **The Ontario Ministry of Natural Resources large-scale forest carbon project: A summary.** Ont. Min. Nat. Resour., Appl. Res. Devel. Br., Sault Ste. Marie, ON. Climate Change Res. Rep. No. CCRR-02. 11 p.
(Forest carbon and how it changes over time provides an indicator of the sustainability of forest management. It is also a sign of sequestration or emission of carbon dioxide between forests and the atmosphere that can affect the mitigation of atmospheric greenhouse gas accumulation and global climate change. To address the need for information on Ontario's forest carbon budget, a large-scale forest carbon modelling project was initiated. The background and objectives of this project are described in this report. Three complementary approaches are being used to estimate large-scale forest carbon storage in Ontario's forests. (1) the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS), (2) a modified version of FORCARB, which is the model developed by the USDA Forest Service to estimate carbon in U.S. forests, and (3) direct estimation of forest biomass carbon using Ontario's growth and yield and forest resources inventory data (CAM, the Carbon Allometry Method). Application of the modelling approaches used in this project will meet the reporting requirements for forest carbon specified by the Kyoto Protocol and associated accords. Further, the results of this project will contribute to Ontario's reporting on Forest Sustainability Indicator 4.1 (Ontario's forest sector contributions to global carbon enrichment).)

Buse, L.J. and A.M. Obenchain. 2005. ***Science Matters II*: Successes and challenges in integrating forest research, science, and policy into planning and practice - synopsis of presentations and discussions**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. Int. Rep. 24 p. + append.
(This report provides a summary of what's been accomplished as a result of recommendations put forward by participants at the 2003 *Science Matters* session and an overview of presentations, discussions, and evaluations of the 2004 *Science Matters II* session. Overall, participants felt that the

presentations at this year's session were interesting and informative; however, many said that there were too many presentations and inadequate time for discussions, resulting in few action items for follow up. Recommendations included revisiting the purpose of the event and the intended audience and ensuring that next year's session is more focused and workshop oriented.)

Candau, J.-N. and (R.A. Fleming). 2005. **Landscape-scale spatial distribution of spruce budworm defoliation in relation to bioclimatic conditions**. Can. J. For. Res. 35(9): 2218-2232.
(Two empirical statistical models were developed to describe the spatial variation in defoliation by spruce budworm, as recorded by Ontario's Forest Health Survey from 1967 to 1998. These models revealed a number of relationships between the spatial distributions of aerially detectable spruce budworm defoliation and bioclimatic conditions over the landscape. A classification tree model relates the northern and southern boundaries of defoliation to the relative abundance of different tree species that host spruce budworm. Between these boundaries, the classification tree uses the maximum winter temperature and the minimum temperature in May to describe where detectable defoliation occurred. A regression tree model uses a total of 8 variables related to winter temperatures, forest composition, spring temperatures, summer temperatures, and precipitation to estimate the defoliation frequency in areas where defoliation was detected at least once from 1967 to 1998. High defoliation frequencies were associated with dry Junes (precipitation, <86 mm) and cool springs (mean minimum temperature < –2.7°C). Conversely, low frequencies were associated with cold winters (mean minimum temperature < –23.3°C; mean maximum temperature > –11.0°C) in the north and a low abundance of host species (percentage of the basal area occupied by balsam fir, white spruce, and black spruce, <14.3%) in the south. Spatial autocorrelation in the bioclimatic variables had little effect on their relationships with the spatial distribution of the defoliation frequency.)

Cole, W.G. and (C.G. Lorimer). 2005. **Probabilities of small-gap capture by sugar maple saplings based on height and crown growth data from felled trees**. Can. J. For. Res. 35(3): 643-655.
(We simulated the probability that sugar maple saplings in single-tree gaps would reach the overstory before lateral gap closure. The model was calibrated with height and crown growth data from destructively sampled trees that ranged from 1 to 27 m tall. Each of the major initial conditions and growth processes was evaluated separately to determine its effect on gap-capture probabilities. Factors such as sapling height at the time of gap formation, continued height growth of border trees, and stochastic growth variation had pronounced effects on the outcome. Stochastic variation generally increased chances of sapling success by delaying closure times in some of the gaps and allowing some saplings to grow at above-average rates. In stochastic simulations with continued (asymptotic) border-tree height growth, probabilities of successful gap capture ranged from <20% of saplings 1 to 2 m tall to 35 to 86% for saplings 7 to 8 m tall. Results suggest that some saplings may be able to capture gaps after one gap event, but probabilities are low for small saplings and for all saplings in small and medium gaps. Based on the mechanisms simulated here, most of the larger single-tree gaps (78 $m^2$) are captured by advance regeneration more than 4 m tall.)

Cole, W.G., (D.I. Farintosh) and (J.L. Todd). 2005. **Ontario hardwood silviculture studies database: Metadata report**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 152. 154 p.
(This report contains printed output of all descriptive information, or *metadata*, for the studies in the *Ontario Hardwood Silviculture Studies Database* available as of March 2003. The database includes more than 90 ongoing and historical hardwood silviculture studies and trials in Ontario, most of which were initiated by the MNR, the Canadian Forest Service, or forest industry. The criteria for inclusion in our database were that the study: (1) occurred in Ontario; (2) included some type of silvicultural treatments and measurements of the resulting regeneration success or growth responses; and (3) focused on one or more of these hardwood tree species: sugar maple, yellow birch, red oak, American beech, white ash, black cherry, or basswood. For each of these studies, we provide all available project metadata, including a project overview, objectives, layout/design, study instigator and associated staff, current contact, silvicultural treatments, measurements, known or expected years of establishment, treatment, and measurement, review methods, comments, data locations, data quality, data stability, tree species, location of study, size, plot type, and known associated publications. The database does not contain any original study field or laboratory data or analyses. To access one or more data sets described in the database, the recommended procedure is to contact the individual listed as the *current contact* for that study to request the data and additional interpretive support.)

Colombo, S.J. (comp.). 2005. **The Thin Green Line: A symposium on the state-of-the-art in reforestation *Proceedings***. Ont. Min. Nat. Resour., Ont. For. Res.

Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 160. 175 p.
(*The Thin Green Line* symposium was attended by nearly 200 professionals, mainly from across Canada and the United States but also included participants from Europe and Asia. The symposium continued Ontario's long and rich tradition in reforestation. Forest regeneration is a cornerstone of managing forests sustainably. Prompt and efficient regeneration gives society the benefits of wood products, as well as the economic wealth that obtaining and processing wood creates. Good reforestation habits provide more wood from less land and increased timber productivity means that demand for wood products can be met with less impact on non-wood uses of the forest. This document is a compendium of invited and volunteer papers and posters presented at the symposium. (Where papers were not submitted, abstracts are provided.) Papers by invited speakers are first, followed by volunteer presentations organized by symposium themes as follows: status of reforestation and afforestation around the world, nursery methods to produce target seedlings, planting and planting site treatments to optimize regeneration, and enhancing timber production and non-timber values through stand establishment.)

Colombo, S.J., W.C. Parker, (N. Luckai), (Q. Dang) and (T. Cai). 2005. **The effects of forest management on carbon storage in Ontario's forests**. Ont. Min. Nat. Resour., Appl. Res. Devel. Br., Sault Ste. Marie, ON. Climate Change Res. Rep. No. CCRR-03. 126 p.
(This report examines how forest management can affect the carbon (C) balance of Ontario's forests. Ten forest management activities organized in 4 themes were examined: stand establishment (site preparation, planting, vegetation management), growth enhancement (thinning, fertilization, genetic improvement), forest protection (from forest fires, and insect and disease infestations), and harvesting (controlling the area occupied by roads, skid trails and landings, reducing the area disturbed by harvesting). The C storage values in this report represent preliminary estimates based on simplified assumptions about forest productivity and species composition. Estimates were obtained from the published literature and by developing a generalized forest soil, litter, and biomass scenario using stand yield data for Site Class 2 black spruce in Ontario. Stand yield data were input into version 2 of the Carbon Budget Model of the Canadian Forest Sector (CBM-CFS2), which has been used to model the C budgets of forests in Ontario and elsewhere in Canada. The effect of forest management practices on stand-level C was scaled to the provincial level using amount of area treated with each practice since 1990. With the exception of thinning, all of the management practices examined can be used to increase forest C storage during a rotation. The practices examined in this report do not all produce large increases in forest C between 2008 and 2012, the first Kyoto accounting period, but over the long term almost always increase both C storage and wood supply.)

Greifenhagen, S., (D.G. Pitt), (M.C. Wester) and F.W. Bell. 2005. **Juvenile response to conifer release alternatives on aspen-white spruce boreal mixedwood sites. Part II: Quality of aspen regeneration**. For. Chron. 81(4): 548-558.
(This study, a component of the Fallingsnow Ecosystem Project, was designed to investigate the effects of conifer release alternatives on the quality of regenerating trembling aspen. A randomized block design was used to compare untreated aspen with aspen growing in areas treated with 2 cutting treatments (brushsaw and Silvana Selective) and 2 broadcast herbicide treatments (glyphosate and triclopyr). The glyphosate treatment virtually eliminated aspen, whereas triclopyr tended to top-kill aspen, resulting in lateral dominance. Both fall cutting treatments generated prolific aspen root suckering and stump sprouting. Stain was common in aspen across the study site in damaged, untreated, and post-treatment stems, indicating that stain develops rapidly in young aspen suckers. Stems damaged by the treatments had higher incidences of decay (33% of cut stems and 10% of herbicide-damaged stems) than untreated aspen (8% of stems); however, decay volume was low for all treatments (1–4% of total stem volume affected). The location of decay (e.g., near ground level in cut stems) and presence of stem crooks in herbicide-treated aspen are important effects of the treatments on aspen quality. Armillaria root disease, which was found throughout the study site, was more prevalent in roots of treatment-damaged and untreated aspen than in suckers that originated post-treatment. These differences can be attributed to proximity to parent stumps, prevalence of root wounds, and older age of damaged and untreated stems.)

Greifenhagen, S. and (M. Cherry). 2005. **Estimating decay in living trees: An assessment of two decay detection instruments.** Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Rep. No. 153. 9 p. + append.
(Wood decay causes substantial wood fibre loss in living trees. In Ontario, information on decay and cull is summarized in provincial cull tables developed prior to the 1960s. These data were recently re-analyzed and revealed gaps in decay data, specifically in overmature and boreal mixedwood stands. As well, decay information is

scarce for second and third generation forests. To fill these information gaps, a practical, operational data collection method is needed. To address this, we tested 2 decay-detection instruments (the Sibert MicroProbe® [DmP] and the Resistograph® F400 [Resi]) to determine their applicability to Ontario's forests. Decay was measured using the instruments as well as a traditional visual decay assessment method at the cut end of 71 sugar maple and 60 aspen logs. Results from both the DmP and the Resi were significantly different than those from the visual method, although actual differences were small. The DmP was faster than the Resi when drilling through soft wood such as aspen, but was not as effective for the harder maple wood. Although slower, the Resi was more versatile as it was able to drill through soft and hard wood, and it was rugged enough for our forest conditions. Training and experience are necessary to properly operate both instruments and to correctly interpret the resulting electronic data sets. The DmP and the Resi detect and quantify decay along a single line through a tree or log. Decay estimation models are currently being developed to convert this linear data into decay volume estimates for the sampled trees. Improved tools for non-destructively assessing decay in trees and logs continue to be developed. These tools have many advantages over traditional decay detection systems: they are faster, they produce an electronic database, and they allow trees to be re-measured to follow decay progression through time. These devices could be a valuable asset to future decay data collection efforts.)

Lu, P., R.W. Sinclair, T.J. Boult and S.G. Blake. 2005. **Seedling survival of *Pinus strobus* and its interspecific hybrids after artificial inoculation of *Cronartium ribicola***. For. Ecol. Manage. 214(3): 344-357.
(Since its introduction from Europe at the turn of the 20th century, white pine blister rust has contributed to the decline of eastern white pine in North America. Tree breeders in Ontario, Canada, have attempted to introduce rust-resistance genes from related white pine species in the subgenus *Strobus*, using traditional plant breeding approaches, i.e., interspecific hybridization followed by backcrossing. In this study, seedlings from advanced generations of selected *Pinus strobus* and its interspecific hybrids were artificially inoculated with *Cronartium ribicola* in the greenhouse. Inherited rust-resistance was evaluated, based on post-inoculation seedling survival. Results indicated that *P. strobus* seedlings suffered high mortality (92–99%) when heavily infected, suggesting a lack of significant genetic resistance to blister rust. Although, the selected *P. strobus* parent trees had been exposed to *C. ribicola* in previous tests, the survival of their progeny was not enhanced under artificial inoculation at the seedling stage. In contrast, some open-pollinated families of the second ($F_2$) and third ($F_3$) generations of *P. strobus* backcross hybrids with *P. wallichiana* have demonstrated significant improvement in post-inoculation seedling survival (>50%). Implications of interspecific hybridization of rust-resistant Asian white pines with *P. strobus* for resistance in the latter are discussed.)

Mallory, E. and W.G. Cole. 2005. **Swan Lake Forest Research Reserve 20-year management plan: 2005-2025.** Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. Int. Rep. 24 p.
(Established in 1950 to study the ecology and silviculture of commercially important hardwood species of south-central Ontario, the Swan Lake Forest Research Reserve is operated by MNR's Forest Research and Development Section (FRDS). The 3480 ha reserve encompasses Great Lakes-St. Lawrence Region forest, small headwater lakes, coldwater streams, and a variety of wetlands. Situated in the southwest corner of Algonquin Provincial Park, the reserve is subject to all Park policies and regulations. FRDS maintains the reserve to provide a secure, dedicated Great Lakes-St. Lawrence Region research forest where this section and its science partners: (1) carry out long-term research projects on forest ecosystem ecology and silviculture in support of OMNR policy and guideline development related to sustainable forest ecosystem management; and (2) deliver extension activities to communicate and visually demonstrate the methods and results of the research to MNR staff, clients, and partners, fellow researchers, and the general public. This management plan supersedes the previous planning document for the reserve, the *Forest Research Plan: Swan Lake Forest Research Reserve* (McLean 1983). It documents the objectives and planned research, extension, and infrastructure activities for the Swan Lake Forest Research Reserve for the next 20 years (2005-2025); identifies how the objectives and planned activities comply with the Park's management plan and other relevant MNR policies and guidelines; and functions as a decision support tool for MNR's Forest Research and Development Section and the Algonquin Park Management Team during all phases (proposal development, review for approval, and implementation) of projects carried out in the reserve.)

Man, R., (K. Greenway) and J. Rice. 2005. **Growth of aspen and white spruce in planted mixtures**. Pp. 107-114 *in* The Thin Green Line: A Symposium on the State-of-the-Art in Reforestation *Proceedings*.

Colombo, S.J., comp. Thunder Bay, ON, 26-28 July 2005. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 160. 175 p.
(This popular summary presents early results of a study established to examine early growth or aspen and white spruce planted in mixtures on a research site in Alberta. Fourth-year results show that more volume is produced in mixed crops than in single crop stands.)

Obenchain, A.M. (ed.). 2005. **Insights**. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. 7(1): 16 p.
(This issue of OFRI's newsletter includes a summary of how research is supporting MNR's strategic directions (*Our Sustainable Future*), an overview of how OFRI's labs support forest research, a five-year update on the Forestry Research Partnership, and summaries of new research projects and publications.)

(Pitt, D.G.) and F.W. Bell. 2005. **Juvenile response to conifer release alternatives on aspen-white spruce boreal mixedwood sites. Part I: Stand structure and composition**. For. Chron. 81(4): 538-547.
(Stand structure and composition for planted white spruce and other naturally regenerating commercial species were compared 7 years after the testing of 5 conifer release alternatives on 3 boreal mixedwood sites. No release resulted in aspen-dominated stands with 89% stocking and the highest basal areas (BA, 5.1 $m^2$/ha) and stem volume indices (SVI, 10.7 $m^3$/ha). Release by manual or machine cutting increased planted spruce BA and SVI by 67 and 38%, respectively. However, this treatment also caused significant root and stump suckering of aspen, more than doubling stem densities and increasing stocking by 12% over untreated areas. Although cutting reduced the height of aspen from 6 m (untreated) to 2–3 m, equal to or just taller than planted spruce, it is likely that future growth will result in deciduous-dominated mixedwoods. Broadcast foliar application with Release® herbicide temporarily reduced the size of aspen, without causing the increased regeneration observed following cutting. This produced a more varied stand structure that promoted the stature of planted spruce, doubling dominant spruce stocking, BAs, and SVIs, and leading to a more balanced mixedwood. Broadcast release with Vision® herbicide produced conifer-dominated stands with few deciduous stems; these areas contained the lowest observed BA (1.7 $m^2$/ha) and SVI (1.9 $m^3$/ha). Relatively low planting densities (1350 sph), coupled with near complete deciduous removal in these plots, created very open-grown conditions that threaten overall productivity and stem quality of the spruce. The approaches tested are capable of producing a range of stand conditions found in a healthy boreal mixedwood landscape.)

(Pitt, D.), B. Parker, F.W. Bell, (A. Morneault), (A. Stinson), (C. Yurich) and (L. Lenteigne). 2005. **Effects of early herbaceous and woody vegetation control on eastern white pine**. Canadian Ecology Centre-Forestry Research Partnership, Mattawa, ON. CEC-FRP Proj. 160-005 Partner Rep. 22 p.
(In 2000, an experiment was initiated to quantify the temporal and spatial effects of woody and herbaceous vegetation on white pine seedlings. A response-surface design is testing different durations of herbaceous vegetation suppression (0, 2, and 4 years) in combination with various timings of woody vegetation release (time of planting, after 2 and 5 growing seasons, and none). The research sites, situated near North Bay, Ontario, and Doaktown, New Brunswick, address the clearcut and 2 gradients of the shelterwood regeneration systems. After 5 growing seasons at the clearcut, white pine subjected to woody-only competition control had 1.1 to 1.2 times the stem volume of pine left untended, earlier release providing the larger gains. In contrast, pine receiving 2 growing seasons of herbaceous competition control averaged 4 times the stem volume of untreated trees. Two seasons of herbaceous control, coupled with woody vegetation control after the second growing season or at the time of planting, increased these gains to 6- and 7-fold, respectively. After 4 growing seasons at the shelterwood sites, woody-only and herbaceous-only competition control were equally effective, providing 3-times the stem volume of untended pine. Early control of both forms of competition increased these gains to 6-fold. These responses to early vegetation control challenge the current operational strategy of planting, waiting 2 growing seasons, and then broadcast releasing with glyphosate (i.e., providing both woody and herbaceous control after the second growing season), which provided 3-fold volume gains over untended pine. Moreover, these early growth responses were strongly associated with observations of seedling physiology and microclimate. In general, low photon flux density and soil moisture content in the top 15 cm of mineral soil were associated with reduced photosynthetic potential of white pine seedlings. Herbaceous vegetation appears to be a greater competitor for soil moisture than woody vegetation during the first two growing seasons after planting, explaining the significant positive gains in white pine growth in response to early herbaceous vegetation control at the clearcut site. After the second growing season, woody vegetation, with its rapidly increasing height and leaf area, become greater competitors for both light and soil moisture. Although light levels

approached critical levels for white pine growth more rapidly in the shelterwood than in the clearcut, moisture and temperature extremes were moderated in the shelterwood environment. White pine height growth and weevil avoidance were greatest with either an aspen or a mature pine (shelterwood) overstory, suggesting that early herbaceous vegetation control and maintenance of a moderate overhead canopy may maximize white pine stem growth and quality.)

(Pitt, D.), (P. Comeau), (C. Man), (M. Mihajlovich), (D. MacIsaac), B. Parker, (S. McPherson) and (A. Stinson). 2005. **Effects of herbaceous vegetation control and aspen stem density on boreal mixedwood stand development**. Canadian Ecology Centre-Forestry Research Partnership, Mattawa, ON. CEC-FRP Proj. 130-301 Partner Rep. 50 p. (Initiated in 2002, this study is intended to increase understanding of the role of vegetation management in establishing intimate mixtures of white spruce and trembling aspen following clear felling on upland boreal sites. The hypothesis being tested is that a relatively low density of white spruce (400 stems per ha) can be planted and managed on an individual-tree basis while aspen are grown to an early technical rotation in the areas between the spruce to optimize the growth of both species. A response surface design that combines the effects of early, radial vegetation control (0, 2, and 4 years duration) with aspen stem density control (400, 800, 1200, 2000, and natural (unthinned)). Following two growing seasons, planted white spruce subject to both woody and herbaceous competition control had 44 to 66% gains in stem diameter over untended trees. Aspen crop trees also benefitted from herbaceous vegetation control with 26 to 43% gains in volume index over stems in untreated or radial woody control plots. Resarch results are intended to improve understanding of early resource use by white spruce and aspen and better information about early mixedwood dynamics to support improved management planning.)

(Smith, W.), (D. Willis) and S.J. Colombo. 2005. **Nine different nursery fertilizer regimes still affecting jack pine plantation growth after 12 years.** Pp. 164-169 *in* The Thin Green Line. A Symposium on the State-of-the-Art in Reforestation *Proceedings*. Colombo, S.J., comp. Thunder Bay, ON. 26-28 July 2005. Ont. Min. Nat. Resour., Ont. For. Res. Inst., Sault Ste. Marie, ON. For. Res. Inf. Pap. No. 160. 175 p. (This popular summary presents field survival and growth of jack pine container seedlings developed under various nitrogen fertilization treatments. In general, high preplant nitrogen improved seedling outplant performance. Results of this study also showed that preplant morphological characteristics were not related to outplant performance.)

# Appendix I: Author Index

This index only includes authors employed by OFRI during 2001-2005 (regional science and information staff matrixed to OFRI for 2002 are in italics). Dates in parentheses indicate year of departure from OFRI, bolded names are research scientists who've joined OFRI since 2000.


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# Appendix III: Forest Research Reports

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# Appendix IV: Forest Research Information Papers

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# Appendix V: Forest Research Notes

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